

COMMERCIAL OILS VEGETABLE AND ANIMAL

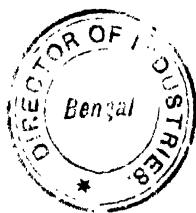
WITH SPECIAL REFERENCE TO
ORIENTAL OILS

BY

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Member American Chemical Society, American Institute of Mining Engineers

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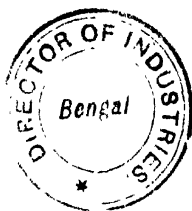
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TO
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IN GRATEFUL ACKNOWLEDGMENT
OF EARLY TRAINING

PREFACE



THIS book is intended primarily for the non-technical man in the oil trade. The writer has attempted to give in it the technical data and information required in every-day dealings in the oil trade, without mixing in a great mass of more or less purely scientific matter.

Trade rules and specifications have been given wherever such exist. The characteristics of the various oils (or constants as they are sometimes less properly called) which are given, are the maximum and minimum values within which most of the samples of oil that will be met with in practice will lie. In general, values which represent what might be termed "freaks" have been omitted. The idea has been to show what values can reasonably be expected, rather than to show the widest variations that can exist. In preparing these maximum and minimum values, determinations of many chemists have been compared, as published in standard text such as Lewkowitsch and Allen, in the technical press, and other sources.

The data on Oriental oils, which are now being imported at Pacific Coast ports, are for the most part results of work in the author's laboratory. Characteristics of these oils have been given separately from the above-mentioned average characteristics. This has been done because it has been found in many cases that a

so-called Oriental oil will differ from the same oil from other parts of the world, to which the oil trade has been more accustomed in times past. In some cases this is due to difference resulting from climate, soil, and other natural conditions. In other cases it is due to the handling the oil receives, sometimes the result of carelessness, and sometimes due to unavoidable commercial conditions.

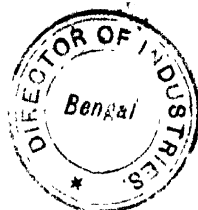
The result in some cases is an oil different in some respects from the oil that commerce is used to. Objection is often made by buyers to such differences. But these Oriental oils have filled a great need in a crisis in the United States, and have won a place for themselves, and as such must be accepted by the oil trade. Buyers must not attempt to make Oriental oils conform to the standards of oil from other countries, but should rather draw new standards for these oils, which will fit their special characteristics.

There is a constant demand for closer grading of these oils. This demand will gradually be met as methods for obtaining and shipping these oils improve. In a commercial movement as new as this is, too much must not be expected at the start. The grading is now probably as close as can be under present methods of handling. Cooperation between buyer and seller will be the best means of improving conditions, and of holding this new trade for the United States in years to come.

I. F. LAUCKS.

SEATTLE, Sept., 1918.

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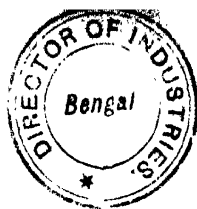
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COMMERCIAL OILS

CHAPTER I

VEGETABLE and animal oils, and fats (as distinct from mineral oils, or petroleums), are compounds of carbon, hydrogen and oxygen which are found naturally in all plants and animals.

The word oils is generally applied to the varieties liquid at ordinary temperatures, and fats, to those solid at ordinary temperatures. Oils and fats are chemical combinations of glycerin as a base with the so-called fatty acids.

The combination forms the so-called neutral oil or fat. There is a large number of different kinds of fatty acids. The different kinds of oils found in nature are due to the number of fatty acids. Any one oil generally has some one kind of acid predominant in it, and along with this predominant acid it will have besides a number of the other acids in smaller amounts. The different acids each have different properties, and impart these differences to the oils in which they occur. No one oil, however, has any fixed combination of the different fatty acids present in it, but the proportions of these will vary with the locality, soil, season, food (in the case of animals), and various other factors. This accounts for differences between the same species

of oil from different places, or harvested at different times.

Examples of the fatty acids, with their occurrence are as follows:

Butyric acid, butter.

Valeric acid, porpoise.

Lauric acid, cocoanut, palm nut.

Palmitic acid, palm, and other vegetable and animal fats.

Stearic acid, animal and vegetable fats.

Arachidic acid, peanut.

Oleic acid, most vegetable and animal oils and fats.

Erucic acid, rape, fish.

Linolic acid, drying oils.

Linolenic acid, linseed and other drying oils.

Ricinoleic acid, castor.

It must not be supposed that any of the above acids are the only acids in the oils named. Thus cocoanut oil, besides lauric acid, will contain stearic, palmitic, oleic, etc., in varying proportions.

General Properties

All oils are lighter than water. When pure they are colorless, but most commercial oils are yellow, or even of darker colors due to impurities. Oils are odorless and tasteless when pure, the taste and odor of commercial oils being due to impurities.

Oils are insoluble in water, but readily soluble in ether, chloroform, benzene, carbon bisulphide, carbon tetrachloride, turpentine, petroleum oils and spirits. They are only partially soluble in alcohol (except castor oil).

They do not give off inflammable vapors unless they are quite hot. They will burn with a wick. They will not distill like petroleum, but decompose under strong heat.¹

If kept from the action of air, light and moisture, oils will remain unaffected for great lengths of time. Oils have been found unchanged which were buried for several thousands of years in ancient tombs.

Oils absorb oxygen from the air. The oils classified as drying oils rapidly absorb oxygen, becoming thick and forming hard films. Linseed oil is an example. The non-drying oils absorb oxygen at a slower rate, and become rancid in the process (see later discussion of rancidity). Moisture and light also cause formation of rancidity.

Rancidity and Free Fatty Acids

The property of an oil developing rancidity and free fatty acids is so important commercially that it is worthy of special attention. Rancidity means practically a disagreeable smell and taste in an oil. When an oil turns rancid the free fatty acids increase. Rancidity and free fatty acids are not, however, synonymous terms, as rancidity is not due to the free fatty acids, but to other substances formed from them.

An oil is a combination of glycerin and fatty acids. When moisture and ferments are present in an oil, the combination of glycerin and fatty acid is gradually broken up, so that part of the glycerin² and part of the fatty acids are present in a free state. This part of the

¹ From 400 to 600° F.

² Glycerin being soluble in water, when free is generally in the water portion of an oil, except when present in large amount. See p. 87.

fatty acids is called the free fatty acid of the oil. This action increases with time. Some oils turn rancid much quicker than others. As an example of what increase may occur in storage of oils the following results obtained in the author's laboratory are quoted:

Oil.	FREE FATTY ACIDS.		
	February.	July,	Increase.
	Per Cent.	Per Cent.	Per Cent.
Fish.....	11.28	11.70	.42
	9.02	9.59	.57
	7.47	7.90	.43
Whale.....	7.19	8.11	.92
Castor.....	1.20	1.20	.0
	.63	1.62	.99
Peanut.....	.63	.99	.36
	.52	1.20	.68
	.14	.21	.07
Extracted bean.....	.35	.35	.0
Refined rape.....	.14	.14	.0
Shark liver.....	.14	.21	.07
Turtle.....	.14	.14	.0
Cocoanut.....	4.23	4.30	.07
	5.53	6.13	.60
	6.63	9.24	2.61
	3.74	4.02	.28

The above samples were stored in tight tin cans at an average temperature of 65° F.

From these results it will be seen that there is considerable variation in the increase of the acids, both between different oils and, also, between different samples of the same oil. These differences depend largely on the degree of refining and care in preparation, and also on the amount of moisture present.

The free fatty acids when acted upon by oxygen of the air and light develop other compounds of bad smell and taste. It is these latter compounds that cause rancidity in an oil. Of course the higher the percentage of free fatty acids the more opportunity there is for the formation of the substances causing rancidity.

Perhaps the most common fatty acid in oils is oleic acid, which is present in some amount in practically all oils. For this reason the percentage of free fatty acid as determined by analysis is usually expressed as oleic acid.

The free fatty acid of cocoanut oil is sometimes expressed as lauric acid, as this acid is present in cocoanut oil in large amount. Percentage of oleic acid is converted to lauric acid by multiplying by 0.71. To convert percentage as lauric to oleic multiply by 1.41. Likewise the free fatty acid of palm oil is sometimes expressed in terms of palmitic acid. To convert percentage as oleic acid to percentage as palmitic acid, multiply by 0.91. To convert palmitic to oleic, multiply by 1.1.

Classification

Lewkowitsch classifies fats and oils according to the readiness with which they absorb oxygen, i.e., their "drying" properties, and, according to whether they are of animal or vegetable origin, as follows:

I. Liquid Fats or Oils:

A. Vegetable oils.

1. Drying oils: linseed, perilla, tung or Chinese wood, soya.

2. Semi-drying oils: cottonseed, corn, sesame, rape.
3. Non-drying oils: peanut, olive, castor, almond.

B. Animal oils.

1. Marine animal oils.
 - a. Fish oils: menhaden, salmon, sardine, herring.
 - b. Liver oils: cod, shark.
 - c. Blubber oils: whale, porpoise, seal, turtle.
2. Terrestrial animal oils: neat's-foot, silk-worm oil.

II. Solid Fats:

A. Vegetable fats. Palm, cacao butter, cocoanut, Japan wax.

B. Animal fats:

1. Drying fats: icebear, rattlesnake.
2. Semi-drying fats: wild duck, horse, rabbit.
3. Non-drying fats: lard, tallow, butter.

The waxes which are related to fats are classified as follows:

1. Liquid waxes—sperm oil.
2. Solid waxes.
 1. Vegetable—carnauba, raphia, palm.
 2. Animal—beeswax, spermaceti, Chinese wax, wool wax.

It will be noted that sperm oil and spermaceti are properly classed as waxes.

Preparation of Oils and Fats from their Raw Materials

In general the methods of obtaining oils and fats are simple. Only the general methods will be discussed here. Any special methods affecting the commercial properties of an oil will be mentioned under the description of that particular oil.

The general methods are the following:

(1) *Rendering*—that is, heating the oil-containing material with water or steam, until the oil exudes from its enclosing cells, and collects on top of the water. It may then be separated. This may be carried out in tanks heated by coils, or in digesters, i.e., boilers into which live steam is injected.

Rendering is chiefly used for animal fats, as lard, tallow, whale oil, and is of little importance for vegetable fats. (See cocoanut oil.)

(2) *Expressing*. This process is chiefly used for vegetable oils. The machines used have been gradually improved from primitive trituration in mortars or wedge presses, to the modern hydraulic press. The process consists simply of forcing the oil out of its cells by pressure. The hydraulic press is the common means of applying the pressure, though crude native methods are still used in some countries.

Practically all edible vegetable oils are obtained by expression, and expression of such oils is done at as low temperature as possible. Oils for technical uses are expressed hot. More oil is obtained from seeds when expressed hot. The quality is, however, poorer. The

first oil expressed is the lowest in free fatty acids and of the best quality.¹

The quality of the oil expressed also depends on the quality of the seeds. The oil in the seeds may become rancid, just as it does after it is pressed. Seeds should be kept dry, well ventilated and out of bright light. Moisture especially will cause the formation of free fatty acids in the seeds and the development of rancidity.

(3) *Extracting.* In this process the oil is dissolved out from other accompanying material by some solvent, in which the oil only dissolves. Such solvents are gasoline (or petroleum ether which is a light gasoline), carbon bisulphide, carbon tetrachloride, benzol, chloroform, acetone, ether. Only gasoline and carbon bisulphide are used on a large scale, the other solvents being too expensive. Extraction processes cannot be used for obtaining oils for edible purposes, as a bad taste will be left in the oil, no matter how carefully or thoroughly the solvent is afterwards separated. Such oils can only be used for technical purposes.

It sometimes happens that the natural odor and flavor of a crude oil prevent the determination by smell and taste whether the oil is extracted or not. If, however, such an oil be refined and deodorized for edible use, the taste and smell of the solvent remaining would be detectable. Chemical methods will give the final answer as to whether an oil is extracted or not.

The solvent used in extracting the oil is, of course,

¹ Two, three, and sometimes more expressions are often made, the first cold, and succeeding ones at higher temperatures. Often expressing is followed by extraction with solvents.

used over and over again. It is separated from the dissolved oil by distillation. A small loss of solvent occurs.¹

Oil Cake

The residue left after the oil has been extracted by one of the foregoing methods is called the cake. Cake from expression processes still contains considerable oil; in some cases as much oil is left in the cake as has been obtained. The amount of oil left in the cake depends on the raw material, temperature, pressure and type of machine used. Cakes from extraction processes contain very little oil.

Cakes are used for stock food and fertilizing purposes. Not all cakes can be used for stock food. Some, as for example castor seed cake, contain poisonous substances. Cakes from extraction processes are sometimes used as cattle food, but generally are not favored for such use, and find their main outlet as fertilizers. The oil left in the cake becomes of value when it is used as a stock food, but has no value when used as a fertilizer.

A stock food is valued on the following components: (The last three being more or less detrimental.)

1. Oil or fats.
2. Carbohydrates, including starch and sugars.
3. Proteids, or nitrogen containing substances.
4. Indigestible matter, called "crude fiber."
5. Mineral matter, or ash.
6. Moisture.

A fertilizer is valued differently, as follows:

¹ Extraction yields higher amounts of oil than expression. Extraction by laboratory methods yields practically 100 per cent of the contained oil. Commercially the yields are somewhat lower.

1. Nitrogen (or ammonia).
2. Phosphoric acid, or bone phosphate.
3. Potash (as K_2O).
4. Moisture.

Nitrogen is the chief fertilizing value in oil cakes.

Refining

Oils, as first obtained, generally contain impurities in the form of fiber and mucilaginous matter, moisture, dirt or insoluble sediment, free fatty acids, etc., and in order to make the best grade, need refining. Refining is done by a number of different methods.

Standing for some time settles out much of the sediment, water, fiber, mucilaginous matter. Standing cold is especially efficacious as some of the impurities are only slightly soluble in oil at low temperatures. Washing out the oils with boiling water is another method of getting rid of some of the mucilaginous matter. Free fatty acids are removed by treatment with alkalis.

Filtration through such substances as fuller's earth, charcoal, etc., is used to clarify and decolorize oils, especially for edible purposes. Treatment with sulphuric acid is used for rape and linseed oils. There are a number of bleaching processes using chemicals. Chlorine, bleaching powder, bichromates, sulphites have been used, along with a number of others. Bleaching by oxygen is done either by exposure to air and sunlight, or the oxygen is introduced as a gas or as ozone.

Edible oils are, in general, the best grade of any oil produced, and need special attention in their preparation and refining. The raw material must be fresh and of the best grade, and the oil extracted as quickly

as possible after harvesting. The oil of first expression, being of the best quality, is used for edible oil. Refining is done by clarifying by fuller's earth¹ or animal charcoal, and free fatty acids are removed by alkalies. Aside from this, however, no chemical processes of bleaching or refining can be used for edible oils. The clarifying and refining takes out, besides the free fatty acids and insoluble matter, any substances such as ferments which would cause later development of free fatty acids and rancidity.²

It is not desirable that edible oils should congeal at low temperatures, that is, they should not deposit a solid fat. The oil is therefore cooled by refrigeration, whereupon the "stearine" settles out or is filtered out. The oil which remains liquid will not deposit any further sediment. This is "winter oil," so-called because it used to be held over wintertime in order to separate out the "stearine."

"Stearine" is the name applied to fats which settle out of liquid oils. These fats are of higher melting-point than the bulk of the oil in which they occur.

Practically any vegetable oil may be used for edible purposes, except certain ones which contain poisonous substances, such as China wood or tung oil, castor, candle-nut and croton.* Aside from such consideration then the judgment as to whether an oil is edible or not rests on its taste and smell.

¹ Fuller's earth is a mineral product resembling clay in its chemical composition. It has a great absorbent power for coloring matter, hence its value in clarifying and decolorizing.

² The loss in weight due to taking out all these substances by refining is called the refining loss. It may be determined in the laboratory approximately. See also specifications for cottonseed, peanut, etc.

Some oils may contain a much higher percentage of free fatty acids than others, and still be edible. Also an oil with no free fatty acids may not be desirable because of a flat taste.

Many attempts have been made to deodorize fish oils to render them fit for edible uses, but so far without much success. Cod liver oil seems to be about the only fish oil that is taken internally, and that without much pleasure.

Oils should be stored at as low a temperature and be kept as free from moisture as possible. If kept from air, light and moisture, oils will keep indefinitely, as has been shown by oils buried with mummies in Egyptian tombs, which have not developed free fatty acids in several thousand years.

Physical and Chemical Properties and Reactions of Oils

Under this head will be discussed briefly a number of technical methods which are used in the examination of oils to determine their quality and purity.

It must be understood that there is no absolute method of determining the purity of an oil, all of the methods used being comparative. For instance, if a chemist is called upon to determine the purity of a sample of table salt, he can determine absolutely the percentage of sodium chloride present, and also the percentage of impurities. Such absolute and exact methods are not applicable in the case of oils unfortunately.

In judging the purity of an oil we have to depend on past experience. Certain properties of oils, which are called "constants" or "characteristics" have been found to have always the same values (within certain

limits) for the same oil. Whenever then, a sample of oil is examined, these characteristics are determined. If their values correspond to the values which the oil in question has been found to possess by past experience, then we conclude it is pure. If the values of the characteristics differ radically from past experience, suspicion is at once thrown upon the purity of the oil. Various special tests are then used to confirm the presence of adulteration.

Other properties are called "variables." The values of the variables vary with the purity, rancidity, age, etc., of the oil. Still other methods of examination are used for accidental impurities.

Important characteristics of oils are: iodine number, saponification number, refractive index, viscosity, specific gravity, titer.

Variables are free fatty acids, color, unsaponifiable matter, acetyl number (except in the case of castor oil where it is a characteristic). Accidental impurities are water, insoluble matter.

Moisture or Water

The determination of water is important from the buyer's standpoint, because he does not wish to pay for water at the same rate as oil. The presence of water also causes oil to become rancid more quickly. Some oils can hold up to about $\frac{1}{2}$ per cent of water and still be clear. Above that amount the presence of water is shown by turbidity. Various crude methods are used for estimating water, but their results cannot be depended on for all oils. Special apparatus and care is necessary for the exact determination of water.

Insoluble Sediment, Dirt, Foreign Substance¹

Includes solid non-fatty matter, remains of animal or vegetable tissue, sand. The determination is important in the case of crude oils which have been prepared without much care.

Specific Gravity

The specific gravity of any one oil will always be very nearly the same. For instance, the specific gravity of soya bean oil from many sources will vary from .922 to .926 at 15.5° C., but will seldom, if ever, fall outside these limits.

Specific gravity is the ratio of the weight of a given volume of oil (or any other substance) to the weight of the same volume of water, the specific gravity of which is arbitrarily called 1.00. For example, the weight of a gallon of soya bean oil is .922 the weight of a gallon of water, and so on.²

Specific gravity also varies with the temperature, and is less, the hotter the oil. (This, of course, is due to expansion of volume by heat.) For this reason, to be comparable, specific gravities always have to be determined at some one agreed-upon temperature. This temperature, whenever possible, is 15.5° C., or 60° F. To change specific gravities taken at any other temperature to that at 15.5° or 60° F. the factor of .00064 for each degree Centigrade, or for each 1.8° F.³ is to be

¹ Also called impurities.

² See p. 133 for weight per gallon of various oils.

³ One degree on the Centigrade thermometric scale is equivalent to 1.8 degrees on the Fahrenheit scale. See p. 134.

either added or subtracted, depending on whether the oil is hotter or cooler than the standard temperature.

If a chemist should report to you a gravity taken at 25.5°C . and you wished to change it to compare with one at 15.5°C ., multiply .00064 by 10 = .0064, and add the product .0064 to the specific gravity determined at 25.5°C . The sum will be the specific gravity at 15.5°C . Specific gravity of all oils is less than 1, ranging from .910 to .965 with some of the waxes above or below (sperm oil) these limits. The determination of specific gravity is important in establishing purity.

Specific gravity is also sometimes expressed by certain empirical scales as degrees. Such a scale is Baumé's scale, which is sometimes used for oils, and very commonly used for petroleum oils. For liquids lighter than water the Baumé degree number increases, the lighter the liquid becomes. A table showing the comparison between the Baumé scale and specific gravity is given on page 133.

Melting-, Solidifying-, and Freezing-points

Neither of these properties is very important in the examination of oils to determine purity. The freezing-point is important in the examination of lubricating oils.

The melting-point of oils and fats is not of much value as an indication of purity, as it is hard to determine by an invariable method, and also the melting-point of natural oils and fats varies considerably.

The melting-point of the fatty acids prepared from an oil is more constant, and is used especially on hard fats.

The solidifying-point of an oil is rarely taken. The same remarks apply as for melting-points. The solidi-

ying-point of the fatty acids is more definite. The titer test is one way of determining the solidifying-point of the fatty acids. It is done under certain standard conditions, that may be exactly duplicated by two chemists working independently.

When the fatty acids solidify, a thermometer immersed in them drops to a certain point at which there occurs a small rise as solidification commences. After this the thermometer again drops. The top point of the rise is taken as the "titer" or "titre." Titer is expressed in degrees Centigrade. This test is much used on lard and tallow to detect foreign admixture. It is also valuable in the examination of fats for candle-making purposes.¹ Titer is a characteristic of the fatty acids of an oil or fat, and as such may be used to establish purity.

The pour test, used for lubricating oils, is used to determine the temperature at which the oil remains liquid, as this point is of considerable importance for such oils. It is carried out under standard conditions.

Cold tests² or cloud tests are used to determine the temperature at which solid matter or stearine separates out of an oil, or the temperature at which an oil will remain clear without such separation. They are used in the case of cottonseed, neat's-foot and sperm oils.

Refractive Index

This is a characteristic of liquid fats or oils which is based on certain properties of the oil in deflecting a beam of light passing through the oil. This deflection

¹ See p. 113.

² See p. 51.

can be measured (by an instrument called a refractometer) and affords a method of determining whether an oil is pure or not. Refractive indices should be taken as a standard temperature (which is usually 40° C.). The temperature at which the determination is made should always be stated.¹

Color

Color in vegetable and animal oils is generally judged by the eye, except in the case of cottonseed oil and some other refined edible oils. Color is determined by an instrument called the Lovibond tintometer. This is an apparatus for matching definite shades of color with the oil under examination, so that its color may be definitely stated.

Cottonseed has for a long time been bought and sold on definite color determinations.² At the present time the tendency is to specify definite colors on other edible oils as soya, cocoanut and peanut.

The Interstate Cottonseed Crushers Association has adopted a standard bleaching test, which determines the color to which an oil, first refined by alkali, can be afterwards bleached by a standard fuller's earth.

Viscosity

Viscosity may be defined as the internal friction of an oil, or its resistance to flow. Oils vary in this property and it may be used in the examination of oils to detect adulteration. It is especially valuable in the examination of lubricating oils. Viscosity is usually measured

¹ Refractive index is especially used in the case of china wood oil.

² See various specifications under cottonseed oil.

by the time taken by a certain volume of oil at a certain temperature to flow through a small orifice. Several styles of apparatus are used, as for instance, Engler's, Saybolt's, Redwood's, Tagliabues'. Each of these gives different results, so that the kind of apparatus on which the determination is made (as well as the temperature), should always be stated. The time of flow is expressed in seconds. The time of flow of the oil in seconds, divided by the time of flow of the same volume of water under the same conditions, is called the "specific viscosity." The higher the temperature the lower is the viscosity. (Which is the same as saying an oil becomes thinner when heated.) The U. S. Bureau of Standards has worked out a table comparing several different viscosimeters, which enables results obtained in one apparatus to be converted to terms of another.

See page 285, Volume XV (1915), Part I, Proceedings American Society of Testing Materials.

It is unfortunate that some one of the various viscosimeters cannot be adopted as standard, thus eliminating the confusion attendant upon converting readings of one to readings of other instruments.

In the following table the oils are arranged in order of their viscosity, castor oil being the highest.

Castor.
China wood.
Olive.
Lard.
Rape.
Neat's-foot.

Peanut.
Linseed.
Cottonseed.

Saponification Value or Number (Koettstoerfer Number)

This is a characteristic value of oils and fats, capable of exact determination, and indicating their purity. It is expressed as the number of milligrams¹ of potassium hydrate (caustic potash) required to completely saponify 1 gram of oil, or in other words, it represents the percentage of caustic potash (expressed in tenths of a per cent) required to saponify an oil. Thus an oil having a saponification number of 200 requires 200 tenths per cent, or 20 per cent caustic potash to completely saponify it.

Besides identifying an oil and establishing its purity, this constant is used by the soap maker to determine the amount of alkalies necessary to combine with a given fat to form a soap, and also as a rough measure of the glycerin content. (See page 116.)

The saponification number of most oils lies between 190 and 200. Exceptions to this statement are rape, castor, fish and liver oils, which are below, and cocoanut and palm nut above these figures.

It must be remembered that unsaponifiable matter in an oil will lower the saponification number, so that the two determinations should always be made together. Likewise large amounts of free fatty acids will raise the saponification number.

¹ A milligram is $\frac{1}{1000}$ gram. A gram is about $\frac{1}{28}$ ounce avoirdupois.

Iodine Number

This is perhaps the most important single characteristic or constant of oils as far as determining purity is concerned. It was noted above that the saponification numbers of most oils varied between 190 and 200, with a few exceptions. Iodine numbers on the contrary run all the way from 1 to over 200. The determination of the iodine number at once therefore places an unknown oil, approximately at least.

The iodine number is defined as the number of milligrams of iodine absorbed by 1 gram of a fat or oil. The determination is carried out by several different methods, (Hübl, Hanus, Wijs) which may give somewhat varying results. It is well, therefore, to state the method employed in making the determinations.

The iodine value and the absorbing power for oxygen run parallel. High iodine values therefore denote drying oils, valuable for varnish, paint, etc.

The table on page 21 gives the commoner oils classified according to their iodine values:

Bromine Value

This is similar to iodine value and is sometimes substituted for it.

Reichert-Meissl, Reichert-Wollny Number

is the number of cubic centimeters of decinormal caustic potash solution required to neutralize the volatile fatty acids distilled in a certain way. In other words, this number is a measure of the fatty acids of an oil which are capable of being distilled. Not many oils contain volatile fatty acids, so that this determination is not

		Iodine Number.
Drying oils.....	Perilla.....	196-206
	Linseed.....	173-201
	Tung, Japanese and Chinese.....	150-170
	Soya.....	130-143
	Poppy seed.....	133-143
Semi-drying oils.....	Maize or corn.....	111-130
	Cottonseed.....	108-110
	Sesame.....	103-108
	Ravison.....	101-122
	Rape.....	94-102
Non-drying oils.....	Almond.....	93- 97
	Peanut or arachis....	83-100
	Rice.....	91-106
	Teaseed.....	85- 90
	Olive.....	79- 88
Fish oils.....	Castor.....	83- 90
	Menhaden.....	139-173
	Sardine.....	161-193
	Japanese sardine....	100-187
	Salmon.....	155-165
Liver oils.....	Herring.....	123-142
	.....	130-170
Blubber oils.....	Scal.....	127-193
	Whale.....	121-146
Vegetable fats.....	Palm.....	51- 57
	Cacao butter.....	32- 41
	Vegetable tallow....	19- 38
	Palmnut.....	13- 17
	Cocoanut.....	8- 10
Animal fats.....	Lard.....	46- 70
	Beef tallow.....	38- 46
	Mutton tallow.....	35- 46
	Butter.....	26- 50
	Sperm oil.....	81- 90
Waxes.....	Carnauba wax.....	12- 14
	Beeswax.....	8- 11
	Spermaceti.....	3- 4
	Insect wax.....	1- 2

very important. It is chiefly used in the examination of butter fat, which has a Reichert number of 26-33. Cocoanut has 7, porpoise oils 23-65, dolphin 6, turtle 5, croton 12-14, maize or corn 4-10. These are the only common oils, however, which have considerable numbers.

Acetyl Value

Certain of the fats on being treated with acetic anhydride combine with a so-called "acetyl" group. Afterwards from such combination, acetic acid can be obtained. The acetyl value is a measure of the ability of oils to react with acetic anhydride. This is especially important in the examination of castor oil, as it has the highest acetyl value of any oil. A number of the other oils have considerable acetyl values, but it happens in the other oils that the acetyl value increases with the age of the oil, so that it is not such a valuable characteristic in the examination of other oils than castor.

Free Fatty Acids and Acid Value or Number

The free fatty acid is that portion of the fatty acid of an oil which is uncombined with glycerin (or other base in the case of waxes) (see page 101). The free fatty acids are not a constant or characteristic of an oil, but change according to age, method of preparation and treatment. Their determination is very important as showing the quality of the oil. For most oils the free fatty acids are expressed as per cent in terms of oleic acid, since oleic acid is the most common of the fatty acids in oils. (See also page 5.) Sometimes the free fatty acids in lubricating oils are expressed in terms

of sulphuric acid, or sulphuric anhydride (SO_3). This does not necessarily mean, however, that sulphuric acid is present in such an oil.¹

The acid value is merely another way of expressing the free acidity. Acid value is converted to percentage of free fatty acids (as oleic) by multiplying the acid number by one-half, or twice the free fatty acids gives the acid number.

Unsaponifiable Matter

Strictly speaking this is all matter in an oil which is not capable of uniting with alkali; that is, saponifying. The glycerin would be included under unsaponifiable with this definition, however, and so the further proviso is added, that so-called unsaponifiable matter must also be insoluble in water. Most oils or fats include some small quantities of naturally occurring unsaponifiable matter, but these rarely exceed 2 per cent (except in liver oils). Larger quantities than this, therefore, at once raise the suspicion that mineral oils are present. Mineral oils are completely unsaponifiable. Sperm oil also naturally contains up to 30 per cent unsaponifiable matter, but sperm oil is properly classed as a wax. The determination of unsaponifiable matter in an oil is especially important to the soap maker, as all unsaponifiable matter in an oil is loss to him as far as soap making is concerned.

Mineral oils, rosin oils, paraffin, ceresin and coal tar oils are looked for in unsaponifiable matter, if this is

¹ Sulphuric acid is sometimes left in oil from refining processes, to the detriment of the oil, hence the origin of this method of expression of the acid content.

unnaturally high in an oil. Special tests are applied for each.

Qualitative Tests

Various tests, for distinguishing certain oils or classes of oils, which do not give results capable of exact measurement, are called qualitative tests. Some of these are as follows:

Elaidin Test. Based on behavior of oils with nitric acid. Non-drying oils give solid products while semi-drying and drying oils give liquid products. This test might be used, for example, to distinguish between a drying and non-drying oil.

Sulphur Chloride Test. When treated with this chemical, drying oils give solid bodies, insoluble in carbon bisulphide, while non-drying oils give soluble products.

The absorption of oxygen may also be used to distinguish between drying and non-drying oils.

Other such tests are heat reactions such as the Maumené test, etc., but these are not much used at present. Formerly much reliance was placed on the Maumené test, which consisted of measuring the rise of temperature due to mixing sulphuric acid with an oil. This method is susceptible to so many errors and uncertainties that it is little used nowadays. It may be used to distinguish between drying and non-drying oils, in a qualitative way.

Color Tests

Formerly various color tests were held to be of much importance. These were especially used to detect small amounts of one oil mixed with another. It has been

demonstrated that most of these tests are not reliable, and they are now little used. Exceptions to this statement are Baudouin's test for sesame oil, Halphen test for cottonseed, Lieberman-Storch for rosin oil.

Examination of the Fatty Acids

Sometimes it is desirable to determine the constants or characteristics of the fatty acids, as some determinations are more exact and reliable when made on the fatty acids than on the original oil. For such determinations the fatty acids are prepared from the oil by saponifying and then setting free the fatty acids from the soap.

In general the same characteristics as previously described may be determined for the fatty acids. It was noted on page 16 that the titer test there described, was the solidifying-point of the fatty acids, and that it was more exact than the determination of the solidifying-point of the original oil. The fatty acids of most oils are insoluble in water. Butter fat, cocoanut oil, cottonseed, lard and tallow, however, contain some amount of fatty acids soluble in water.

Aside from the titer test, however, the examination of the fatty acids is not very important in the commercial examination of oils, but is used in special examinations to detect adulteration, etc.

Cholesterol and Sitosterol (Phytosterol)

These are substances occurring in the unsaponifiable matter of oils and fats. Cholesterol occurs only in animal fats and oils, while sitosterol (or phytosterol) occurs in vegetable oils. The presence of sitosterol

therefore in an animal fat, would indicate admixture of vegetable oil, and vice versa.

Examination of Oils for Purity

The foregoing properties and reactions of oils are largely used in determining the purity of a sample of oil. The common determinations made for this purpose are specific gravity, iodine, and saponification numbers, per cent of unsaponifiable matter. Along with these are generally made special tests for each individual oil. These special tests will be enumerated under the description of the individual oil. If the constants as listed above are found to be within the limits as defined by past experience for the oil in question, and the special tests are satisfactory, it is pronounced pure.

To illustrate, a few examples will be given:

A sample of rapeseed oil is analyzed and the constants are found to be

Specific gravity at 15.5° C . . . . .	.9151
Saponification number	174
Iodine number	100
Unsaponifiable matter	1.2%

By reference to tables it is found that past experience has shown the following limits for these constants:

Specific gravity at 15.5° C . . . . .	.913-.917
Saponification number	170-179
Iodine number	97-106
Unsaponifiable matter . . . . .	.5-1.5%

It is noted that the characteristics of the sample under examination fall well within these limits. The

presumption is that it is pure. Besides these tests, however, the following special tests are often made on rapeseed oil: viscosity, freezing-point, Halphen test for cottonseed, Baudouin test for sesame, titer. If the viscosity, freezing-point, and titer are within the limits of past experience, and the Halphen and Baudouin tests give negative reactions, then the chemist is warranted in saying that the sample is pure.

But suppose the Halphen test for cottonseed had given a positive reaction. Then regardless of the fact that the specific gravity, iodine number, saponification number, etc., were within the limits for rapeseed oil, the chemist would pronounce the oil adulterated.

It will be noted by reference to cottonseed oil that its average saponification number is 194, its iodine number 111.

- The average constants for rapeseed and cottonseed oil are as follows:

	Rapeseed	Cottonseed.
Specific gravity.....	.915	.9245
Iodine number.....	101	111
Saponification number...	175	194

A mixture of 90 per cent rapeseed with 10 per cent cottonseed would then have the following values, if we assume the above values in the original constituents:

Specific gravity.....	.915
Iodine number.....	102
Saponification number.....	177

It will be noted that these values are still within the limits for rapeseed oil. Hence the value of the special Halphen test for the presence of cottonseed oil. Ten per cent cottonseed would also diminish the viscosity of the mixture enough to be noticeable, unless the viscosity of the original rapeseed oil had been specially high.

Suppose now that it had been attempted to mix 10 per cent of a fish oil having an iodine number of 170, with 90 per cent rape oil. The iodine number of the mixture would be 108, which is above the high limit for rapeseed oil, and would at once throw suspicion upon it. The specific gravity and saponification numbers would still, however, be within the limits for rapeseed. In this case the presence of cholesterol in the unsaponifiable, the yield of bromides and viscosity, would give confirmatory evidence of the adulteration.

As contrasted with the above method of examination may be cited the case of castor oil, whose characteristic solubility in alcohol and petroleum ether is a quick and easy method of establishing its purity. China wood oil is also tested by a special heat test (see page 38), which affords a quick method of determining admixture of other oils.

Such cases as these, however, are the exception in the examination of oils, and most opinions as to the purity of the oil in question must be based on examinations similar to the first example. It is seen, therefore, that such an opinion can rarely be based on the results of any single determination. Practically always confirmatory evidence must be obtained by the determination of several characteristics and by various special tests.

It must also be remembered that the same oil from different localities will vary considerably in its properties. Also an oil-bearing plant may be introduced into a new country, with new climatic conditions, soil, etc., and the oil produced may have somewhat different characteristics than have been determined by past experience, based on oil from the plant in its native country.

With animal fats the food of the animal often influences the nature of the fat. For example, lard from pigs fed on cottonseed meal has a higher iodine value than other lard.



CHAPTER II

IN the following descriptions of oils, the characteristics and properties given in standard texts such as Lewkowitsch, Allen, etc., and various articles in technical journals have been given. Afterwards any deviations from such published results, as a result of the author's experience on Oriental oils as imported at Pacific Coast ports, have been noted.

Perilla Oil

China, Japan (Hokkaido), Eastern and Northern India, Southern Manchuria. Sown in April. Ripens in September. Several species are known. Attempts have been made to raise in United States, but were abandoned on account of unsatisfactory cake, which has peculiar aromatic taste and smell.

Has highest known iodine number of any oil, but drying power (oxygen absorbing) is not as high as linseed. Used as substitute for linseed in printer's inks, varnishes, paints. In its native countries used for edible purposes. Also in Japan in preparation of artificial leather, paper goods, etc. It has a property of forming drops when spread on surfaces, so that it is inferior to linseed for varnish purposes.

Characteristics

Specific gravity at 15.5° C.....	.928-.936
Saponification number.....	188.6-190.6
Iodine number.....	196-206
Refractive index 40° C.....	1.4753
Melting-point.....	-5° C.

Perilla oil from China and Japan runs as high as .935 in specific gravity. Acids will run as high as 6 per cent. Saponification number may be as high as 195. Some oil shows cottonseed oil admixed. The oil is generally dark colored. On heating it bleaches, and most samples do not deposit sediment on heating. Not a great deal of perilla oil is imported.

Linseed Oil, Flaxseed Oil

Argentina, United States, Canada, India, Russia China. Russian Baltic seed gives the best oil. Canadian oil is about the same. Argentine, Indian and United States seed give poorer grade oil. Argentina, Russia, India, United States, and Canada were chief producers in the order named before the war.

The carefulness with which the seed is harvested influences the character of the oil. Hemp, ravisson, rape and cameline are the commoner foreign seeds present in linseed.

Proportion of Oil in Seeds

	Per Cent.
Russian linseed.....	32-38
Indian linseed.....	37-43
River Plate linseed.....	35-36
N. American linseed.....	36-38
Levant linseed.....	37-42
Hungarian linseed.....	36-38
Morocco linseed.....	36-40
Sicilian linseed.....	41-42
Chinese linseed (yellow-brown)....	31-38

Specifications of Chicago Board of Trade for flaxseed are as follows:

SECTION 1.—The weight per measured bushel designated for each grade shall be that of commercially pure seed.

No. 1 Northwestern Flaxseed.—Flaxseed to grade No. 1 Northwestern shall be mature, commercially sound, dry and sweet. It shall be Northern grown or have the usual characteristics thereof. The maximum quantity of field, stack, storage or other damaged seed intermixed shall not exceed twelve and one-half per cent. The minimum weight shall be fifty-one (51) pounds to the measured bushel.

No. 1 Flaxseed.—No. 1 flaxseed shall be commercially sound, dry and free from mustiness, and carrying intermixed not more than twenty-five per cent of immature or field, stack, storage or other damaged flaxseed, and weighing not less than fifty (50) pounds to the measured bushel.

Rejected Flaxseed.—All damp and must flaxseed and that carrying intermixed, immature or field, stack, storage or other damaged flaxseed in excess of twenty per cent, and weighing not less than forty-six and one half (46½) pounds, shall be graded "Rejected."

No Grade Flaxseed.—Flaxseed that is wet, mouldy, warm or in a heating condition, or is in anywise unfit for temporary storage, or weighs less than forty-six and one-half (46½) pounds, shall be graded "No Grade."

Flaxseed that is smoky, burnt, or intermixed with burnt seed, shall not be known by any grade, but shall be inspected in the usual way to determine percentage of impurities, and shall be posted as "Burnt or Smoky Flax."

Seeds are either hot pressed, cold pressed or extracted by solvents. Hot pressing yields the best oil for technical purposes, extracted oil not being considered as good. Cold pressed oil is used for edible oil in Russia, Germany and India. Hot pressing also gives the best cake for cattle food. Only hot-pressed cake should be fed to cattle, as cake pressed at too low a temperature is liable to develop poisonous prussic acid, while hot pressed cake is not liable to this danger. Cakes not suitable for cattle food are used as fertilizers. Cake contains on an average:

	Per Cent.
Oil.....	4-8
Albuminoids or crude protein.....	30-40
Crude fiber.....	8-12

Twenty-three to 28 per cent by weight of the seed is obtained as oil. Nearly 10 per cent of oil remains in the cake. Cold pressing gives pale edible, and also good drying oil. Hot pressing gives dark oil. Oil extracted by carbon bisulphide has garlic odor and is dark red.

Linseed oil is much improved by standing in tanks and by exposure to light allowing the foreign substances to settle out. Some is refined by sulphuric acid, and some by alkali, the latter being used to bleach dark oils. Best grade of linseed made by sun bleaching is called "artists' oil."

Raw oil is the original oil obtained from the seeds. Refined oil is oil obtained from the raw by one of the foregoing processes. Boiled oil is oil that has been heated and to which has been added certain substances known as "driers." Manganese and lead compounds are commonly used. A substitute boiled oil called "bung oil" is obtained by adding a drier to the oil but not heating it. Boiled oil is red-brown in color, darker than raw oil. "Double boiled oil" is heated longer or with more drier added. It is darker in color.

Linseed oil is used chiefly in the paint and varnish industry, for which it is preeminently suited, as its properties make it the best drying oil known. Its use in putty, oil cloth, leather cloth, linoleum and printer's ink depends also on its drying properties. In general the higher the specific gravity and iodine number the better will a linseed oil be for the above uses. It is also used for soap, and rubber substitutes. Linseed oil is hydrogenated to a solid fat which is used in soap. Substitutes for linseed oil are perilla, Chinese and Japan-

ese wood, or tung oil, cottonseed, soya, fish, and other semi-drying oils.

The "drying" property of linseed, and other drying oils, is their ability to take up oxygen from the air, forming a hard coating when a thin film is exposed to the action of the air. Good linseed oil should "dry" thus in less than three days. It should not be "tacky" (or sticky) to the fingers, and should form a good elastic coherent skin. Samples of linseed are compared with known good oils by coating glass plates and leaving them stand under similar conditions.

The important characteristics to be determined in judging the purity of a sample of linseed oil are: Specific gravity, iodine number, oxygen absorption, unsaponifiable matter and saponification number. Halphen test is applied for presence of cottonseed oil. Yield of hexabromides and their melting-point is used to detect adulteration by fish oils.

Low iodine number indicates adulteration. Presence of fish oils can be detected by behavior of hexabromides in melting, also by cholesterol test. Adulteration with mineral and rosin oils is detected by unsaponifiable matter and saponification number.

A test for the suitability of linseed oil for the paint and varnish trade is as follows: Heat a small amount of the oil in a test tube until it begins to boil up, about 600° F. Good oil remains clear on cooling and generally becomes lighter in color. From inferior oils insoluble matter or foots will separate out and settle to the bottom of the test tube. In still poorer oils this matter does not settle, but remains suspended in the oil.

The U. S. Government Specifications for linseed oil are as follows:

The oil must be strictly pure, well-settled linseed oil, perfectly clear, and not show any deposits of "foots" or a loss of more than 0.2 per cent, when heated for one-half hour to a temperature of from 103° C. to 105° C.; it must show on examination the following characters:

	Maximum.	Minimum.
Specific gravity at 15° C.	0.936	0.932
Specific gravity at 25° C.	0.931	0.927
Iodine value (Hanus)	190	178
Saponification value	192	189
Acid-value ¹	3	
Refractive index at 25° C.	1.4805	1.479
Unsaponifiable matter, per cent	1.5	

The oil, when poured on a glass plate and allowed to drain and dry in a vertical position, guarded from dust and exposure to weather, must dry free from tackiness in less than 75 hours at a temperature of from 15.5° C. to 26.5° C.

The specifications of the American Society for Testing Materials are as follows:

Specific gravity at $\frac{15.5^{\circ}\text{C.}^2}{15.5^{\circ}\text{C.}}$ .....	.932 to .936
Specific gravity at $\frac{25^{\circ}\text{C.}}{25^{\circ}\text{C.}}$ .....	.927 to .931
Acid number ³	not over 6.0
Saponification number	189 to 195
Unsaponifiable matter	not over 1.50
Refractive index at 25° C.	1.479 to 1.4805
Iodine number	not less than 174

¹ Free fatty acids, 1.5 per cent.

² This manner of expressing temperature at which specific gravity is taken, means the specific gravity of the oil at 15.5° C. is compared to that of water at 15.5° C.

³ Free fatty acids, 3.0 per cent.

Characteristics:

Specific gravity at 15.5° C...	.931-.941	
Solidifying-point.....	Stearine deposits at -25° C.	
Melting-point.....	-16° to -20° C.	
Saponification number.....	188-195	
Iodine number.....	170-205	
Refractive index 20° C.....	1.480-1.482	
Unsaponifiable matter.....	1-2%.	Usually solid
Titer.....	19.0-20.6° C.	
Bromides (on fatty acids)...	29-42%	
Melting-point of bromides..	175-180° C.	
Flash-point (closed cup)....	450-500° F.	

Boiled Linseed Oil

Linseed oil heated to a temperature of 210 to 260° C. in presence of substances called driers, such as lead and manganese compounds, undergoes a change in color, specific gravity and drying properties. Boiled oil dries in twelve hours, where raw linseed oil takes three days. The characteristics of boiled oil are different from raw linseed oil. For example the iodine number varies from 70 to 160. The specific gravity is higher and the yield of bromides lower. The color is darker. The mineral matter (lead, manganese) easily distinguishes a boiled oil. It may be adulterated with rosin, rosin¹ or mineral oils, fish or tung oils. Adulterations are harder to detect in boiled than in raw oils.

¹ Rosin oil is the heavier part of the distillate obtained by distilling pine resin. Rosin is the residue left from such distillation.

China Wood Oil, Chinese Tung Oil, China Nut Oil

From the nuts of two varieties of a tree native of China, Indo-China, Tonkin, Annam, the tung yu shu and mu yu shu, the first being the most important. Provinces of Szechwan, Kweichow, Hunan and Northern Hupeh are most important in the order named. Szechwan oil has the palest color. The tung yu tree grows in the above provinces. The mu yu tree grows in Kwangsi. This gives the South China oil and its principal market is Wuchow; while the oil from the first named provinces is marketed from Hankow, by which name this grade is often called.

The two trees yield practically the same oil chemically. The difference between the grades appears to be mainly due to differences in methods of handling. It is obtained in a crude way by small producers and collected at Hankow by middlemen, where it is clarified and shipped. Cakes are poisonous and only used for fertilizer. By some it is claimed that the oil itself is poisonous. Cold pressed oil is pale; hot pressed, dark. It has a peculiar smell, said to be absent from fresh pressed oil. On keeping, the oil jellies or solidifies or polymerizes. Crystals form which increase with time.

While wood oil dries more quickly than linseed oil, it does not give an elastic film, but a waxlike opaque skin. When heated to 500° F. for a short time it solidifies to a jelly-like mass.¹ This property forms the basis of heat tests of China wood oil, which are very useful in determining its purity.

On account of the high price of this oil it is often adulterated. Soya bean, sesame, cottonseed, etc., have

¹ Called polymerization.

been found. The New York Produce Exchange has adopted the following specifications:

CHINA WOOD OIL

SEC. 25.—Pure China wood oil shall answer the accepted chemical requirements.

SEC. 26.—Commercially prime China wood oil shall be pale in color (according to season's production), merchantably free from foots, dirt and moisture; the total impurities shall not exceed 1 per cent; but, unless otherwise provided for, impurities not plainly adulterations, up to 5 per cent, shall not justify rejection, but allowance shall be made by sellers for such impurities in excess of 1 per cent. The oil shall stand the heat test, herewith subjoined.

HEAT OR COAGULATION TEST FOR CHINA WOOD OIL¹

One hundred grams of the oil is heated in an open metal pan, six inches in diameter, as rapidly as possible, to a temperature of 540 degrees F. The time required to heat the oil from room temperature to 540 degrees should be, as nearly as possible, the same each time, four minutes being usually sufficient with gas burners. Hold the oil at or as near to 540 degrees as possible, stirring until it begins to solidify. Note the time required after the oil reaches 540 degrees and until it begins to solidify. This should not exceed $7\frac{1}{2}$ minutes for any commercially prime wood oil. When the oil has solidified in the pan, turn it out, while still hot and cut with a knife. Commercially prime wood oil gives a product that is pale, firm and cuts under the knife like dry bread, not sticking. If the oil requires more than $7\frac{1}{2}$ minutes after reaching 540 degrees until beginning to solidify, or if the product is dark, soft or sticky, the oil may be rejected.

Other heat tests are Bacon's, Browne's and the Pratt and Lambert tests. In Bacon's test the oil is heated nine minutes and compared in behavior with a known pure sample of oil. In Browne's method the oil is heated in test tubes and must set within twelve minutes.²

These heat tests, together with determination of

¹ Known as the Worstall test.

² Browne's test has been adopted by the American Society for Testing Materials.

specific gravity, iodine number, saponification number, refractive index, etc., ordinarily determine the purity of China wood oil.¹ The specific gravity is higher than in any oil save castor.

China wood oil is largely used as a substitute for linseed oil in varnish, waterproofing for cement, linoleum and paint, because of its rapid drying properties. It is used extensively in China for waterproofing fabrics, paper, for varnish, putty, lacquer and ink. The fatty acids are used as a substitute for shellac.

Attempts have been made to introduce the tree into California and Southern States in the United States, where it is said to thrive.

Characteristics

Specific gravity at 15.5° C. ....	.9406-.9440
Solidifying-point.	2-3° C.
Saponification number.	190-197
Iodine number.	150-176
Refractive index 20° C.	1.5111-1.5207
Viscosity (Redwood 60° F.)	850-1430 secs.
Unsaponifiable matter. up to	.8 per cent
Free fatty acids. up to	5.30% (Oleic)
Titer.	37.1° C.

Japanese Tung Oil, Japanese Wood Oil

From fruits of tree grown in Japan. This oil does not gelatinize in the heat test like China wood oil, but becomes thicker. It is not as good drying oil as China wood oil, but is a cheaper substitute for it, and for linseed. The cake is poisonous, but is said to lose its

¹ Often the heat tests are used alone to determine purity, but this is not good practice, and often gives misleading results.

harmful properties when hot pressed. Not much of this oil is exported.

Characteristics

Specific gravity at 15.5° C.....	.9330-.9400
Saponification number.....	185-197
Iodine number.....	149-161
Refractive index 25° C.....	1.5034-1.5099

The presence of this oil in China wood oil would be detected by the heat tests given under China wood oil.

Candle Nut Oil, Lumbang Oil

From the seeds of a tree widely distributed throughout the tropics, Pacific Islands, Florida, Brazil, West Indies, Africa, India, China. Cultivated in Hawaii and the Philippines. It is used there for soap, paints and varnish. Seeds contain over 60 per cent of oil.

The oil cannot be used for edible purposes on account of its purging properties. Used to some extent in paints or varnishes on account of its drying properties, which, however, are not so good as linseed. Linseed oil may be adulterated with it. Also used in soap, especially for soft soaps. The natives use it as a burning oil, as its name indicates. Experiments show that it may have good value as a varnish oil.

Characteristics

Specific gravity at 15.5° C.....	.920-.930
Saponification number.....	191-195
Iodine number.....	158-165
Unsaponifiable matter..... up to	0.53%
Bromides (fatty acids).....	11-12%
Refractive index 25° C.....	1.465-1.475
Titer.....	17-18° C.

Stillingia Oil, Tallow Seed Oil

Obtained from seeds of the same tree from which vegetable tallow is obtained in China.

It has drying properties and is used as adulterant for China wood oil.

Characteristics

Specific gravity at 15.5° C.....	.939-.946
Saponification number.....	203-210
Iodine number.....	145-160
Titer test.....	12.2° C.

Hemp Seed Oil

Hemp is cultivated in Europe, North America, India, Japan, China and Manchuria. Used as paint oil, in varnishes, soft soaps, and for edible purposes. Oriental hemp seed comes mainly from Manchuria.

Characteristics

Specific gravity at 15.5° C.....	.925-.931
Saponification number.....	190-193
Iodine number.....	140-166
Titer.....	15.6-16.6° C.
Solidifying-point.....thickens at	-15° C.
“.....solidifies at	-27° C.

Hemp seed oil has good drying properties and it would seem that it should have a future in this use. Not a great deal has been imported from China or Japan. The oil is dark green as a rule, and rather cloudy and with some sediment. Acids are low, 1 to 2 per cent. Iodine number runs above 160. Unsaponifiable matter .5 to .7 per cent. Titer around 10° C., saponification

number 193. Refining loss for 1.2 per cent acid oil, is 8.5 per cent, giving a yellow oil with a tinge of green. On heating the crude oil becomes somewhat lighter in color.

Walnut Oil

From common walnuts. Nuts are kept several months before pressing, as fresh nuts give a turbid oil. Nuts contain up to 65 per cent oil. Cold-pressed oil is nearly colorless. The oil has good drying properties and is used in special grades of paints for artists' use. Such paints are less liable to crack than linseed oil paints. Walnut oil is generally high priced and may be adulterated by linseed, poppy, etc. High acid oil is unsuitable for paints and is used for soft soap. Good grade oil is used in Europe for edible purposes.

Characteristics

Specific gravity at 15.5° C.....	.9256-.9265
Saponification number.....	192-197
Iodine number.....	143-151
Solidifying-point..... thickens at	-12° C.
“..... solidifies at	-27° C.
Viscosity at 70° F. (Redwood).....	232 sec.

Soya Bean Oil (Soja bean, Soy bean, bean, Chinese bean oil)

Obtained from several plants native in China, Manchuria, Japan, Formosa, Korea, Indo-China. Oil and cake have been used for edible purposes in these countries for thousands of years.

The beans average as follows in composition:

	Per Cent
Oil.....	18
Water.....	10
Albuminoids.....	40
Carbohydrates.....	22
Crude fiber.....	5
Ash.....	5

Some varieties contain nearly 23 per cent oil. The pressed cake is specially valuable as a cattle food on account of the high content of albuminoids (or proteids). It has been found that the milk from cows fed with soya bean cake is richer in butter fat. The cake is also used largely for human food, and there are a number of different ways of preparing it. Certain fermented liquors are also made from it. The extracted meal is only used for fertilizer, although it has been used in cattle foods.

Crude native processes of expression yield up to 13 per cent of oil, while some modern mills only obtain 10 per cent. Further amounts are obtained by an extraction with solvents. Many mills use extraction by solvents as the only process, naphtha being most commonly used.

The expressed oil from sound beans is low in acid. Higher acid oil may be refined in a similar way to cottonseed oil. For edible purposes the oil is bleached with fuller's earth, for technical purposes by chemicals.

The oil is used for soap making chiefly. It makes a softer soap than cottonseed. Good grades of oil are also used for edible purposes. A considerable quantity goes into the paint and varnish trade. Soya bean is considerably slower in drying than linseed.

It is considerably used in boiled oils for paints. Tungate and cobalt driers are said to be most suitable for soya bean oil. Varnishes of soya bean oil do not give good skins.

For paint oil a sample should stand the following tests: (1) It should become pale on heating to 500° F. and remain so. (2) When blown with dry air for five to seven hours the specific gravity should be .960 or more.

Characteristics

Specific gravity at 15.5° C. ....	.922-.928
Saponification number.....	190-194
Iodine number.....	114-143
Solidifying-point.....	-15 to -8° C.
Titer.....	21° C.
Unsaponifiable matter....less than	1 per cent

Grades for soya bean oil suggested by the New York Produce Exchange, April 15, 1918, are as follows:

SOYA BEAN OIL

SEC. 6.—Fair average quality crude shall be oil obtained from the soya bean by pressure, not extraction, and shall be fair average quality of the season, provided, however, that the free fatty acids shall not exceed 2 per cent (calculated as oleic acid), nor moisture and impurities one-half of 1 per cent.

SEC. 7.—Prime crude soya bean oil shall be free from water and settlings, and shall refine to a color not deeper than 35 yellow and 9 red, and with a loss not to exceed 5 per cent with the use of caustic soda. If not prime, the buyer may reject.

SEC. 8.—Crude soya bean oil, sold "basis 7 per cent refining loss," shall be free from water and settlings, and refine to a color not deeper than 35 yellow and 11 red and with a loss not to exceed 7 per cent with the use of caustic soda; provided that any oil that refines with a greater loss than 7 per cent shall not be rejected, but price shall be adjusted as per rule 7, section 1.

SEC. 9.—Extracted soya bean oil shall be sold on sample or guarantee with the designation of the country of origin.

The Interstate Cottonseed Crushers Association rules are as follows:

SOYA BEAN OIL—GRADES

RULE 25. *Section 1.*—Prime Soya Bean Oil shall be pressed, and not extracted from Soya Beans, free from water and impurities, and shall refine with a color not to exceed 35 yellow and 9 red, and with a loss not to exceed 5% with the use of Caustic Soda by methods adopted by the Chemists' Committee to which it is referred. Provided that any oil that refines with a greater loss than 5% shall not be rejected but shall be reduced in price by a corresponding per cent in the contract price of the oil.

Sec. 2.—Crude Soya Bean Oil sold basis 7% refining loss, shall be pressed and not extracted from Soya Beans and shall be free from water and impurities and refine with a color not to exceed 35 yellow and 11 red, and with a loss not to exceed 7% with the use of caustic soda by methods adopted by the Chemists' Committee to which it is referred. Provided that any oil that refines with a greater loss than 7% shall not be rejected but shall be reduced in price by a corresponding per cent in the contract price of the oil.

Most of the soya bean received from the Orient is low in free fatty acids, less than 2 per cent. The extracted oil contains generally less than 0.5 per cent acids. The latter oil is yellow, while the pressed oil is more of a brownish color.

The following table shows the character of oils imported at Seattle:

FREE FATTY ACIDS

Pressed Oil.	Under 1%	1-2%	2-4%	4-6%
January-June, 1918.....	72 ¹	21	7	0
June-August, 1918.....	76	10	4	10
Extracted Oil.				
January-August, 1918.....	100			

¹72% of samples analyzed contained under 1% free fatty acids, and so on.

Averages of a number of determinations on Seattle imported oil are as follows:

	Pressed Oil.	Extracted Oil.
Specific gravity at 15.5° C.....	.9260	.9248
Saponification number.....	193.8	193.5
Iodine number.....	134.5	131.9
Unsaponifiable matter, per cent..	0.63	0.66
Titer, deg C.....	18.2	16.3
Refining loss, per cent.....	4.8	3.5
Solvent left in oil, per cent.....	.....	1.0

Pressed oil passed the heat test described above.¹ Soya bean oil is imported in the largest quantity of any individual oil. Up to the present time it has been sold as f.a.q. (fair average quality).² Several proposals have been made lately tending towards establishment of grades, as above mentioned.

Poppy Seed Oil

From poppy plant. Grown largely in India, Egypt, Persia, Asia Minor, Russia, France. Also Manchuria, but latter oil is low quality. It is an important oil in Europe.

Used as edible oil, also as adulterant of olive oil, for fine artist's paints. (See walnut oil.)

Commercial oil generally contains accidental admixture with sesame. The cold-pressed oil is the grade known as "white" oil, while hot pressing gives the "red" grade.

¹ P. 44.

² This means fair average quality of the season's production for any given district. As a matter of fact, just what this fair average quality is, would be a very difficult matter to determine. It is a very poor way to grade oil.

Characteristics

Specific gravity at 15.5° C.....	.924-.927
Saponification number.....	189-197
Iodine number.....	137-157
(Low values due to mixture of sesame.)	
Solidifying-point.....	-18° C.
Titer.....	15-16° C.

Sunflower Oil

Used extensively in Europe. Cultivated in Russia, Hungary, India, China. Seeds contain up to 53 per cent oil. It is a slow drying oil, but is used nevertheless in some varnishes; also for soap, and edible purposes.

Characteristics

Specific gravity at 15.5° C.....	.924-.926
Saponification number.....	188-194
Iodine number.....	119-135
Solidifying-point.....	-16 to -18.5° C.

Corn Oil

From the germs of corn, separated in making of starch and glucose, and in alcohol distilleries. The germs are separated from the starch and pressed. The edible oil is refined and deodorized by superheated steam. If it stands in contact with albuminoid matter, it undergoes fermentation with resultant high acids and dark color, so that it has to be bleached for light soaps. The crude oil can be identified by a taste similar to corn meal. It is a semi-drying oil, with better drying properties than cottonseed. Used for salad oil, often mixed with cottonseed or other edible oils. Also in manufacture of margarin and compound lard, and for

baking use. Oil not fit for edible use is used for soft soap. It is not fitted for hard soap. It is not suitable for paints or lubrication, although it is sometimes used for paint. Also used in rubber substitute.

Characteristics

Specific gravity at 15.5° C.....	.921-.928
Saponification number.....	189-192
Iodine number.....	121-131
Solidifying-point.....	-10 to -36° C.
Stearin deposits at ordinary temperature on standing.	
Unsataponifiable matter.....	1.4-2.3%
Titer.....	19° C.

Cottonseed Oil

From seeds of the cotton plant in United States, Egypt, India, Brazil, Peru, Russia, W. Africa.

The seed is crushed with or without removing husk, depending on whether fiber adheres or not. Whole seeds yield from 16 to 24 per cent oil, kernels alone yield from 34 to 39 per cent. In Europe seeds are usually crushed whole, that is, husks and kernel together. In the United States the seed is usually decorticated. Husks remaining in the cake are not harmful to cattle, but fiber adhering causes stomach troubles. Cake averages about 10 per cent oil.

Cottonseed cake is graded as follows by the Interstate Cottonseed Crushers Association:

COTTON SEED CAKE

RULE 9. Sec. 1.—Cotton Seed Cake is a product of the Cotton Seed only, composed principally of the Kernel, with such portion of the fiber or Hull and Oil as may be left in the course of manufacture, and shall be graded and classed as follows:

Sec. 2.—Choice Cotton Seed Cake must be bright yellow in color,

sweet in odor, friable in texture, not burnt in cooking, free from excess of lint, and shall contain not less than either eight per cent of ammonia, or forty-seven per cent of combined protein and fat.

Sec. 3.—Prime Cotton Seed Cakes must be of good color, yellowish, not brown or reddish, sweet in odor, firm but not flinty in texture, free from excess of lint, and shall contain not less than either seven and one-half per cent of ammonia, or forty-three per cent of combined protein and fat.

Sec. 4.—Sound Cotton Seed Cake must be of good color, not brown or reddish, sweet in odor, firm but not flinty in texture, free from excess of lint, and shall contain not less than either seven per cent of ammonia or forty per cent of combined protein and fat.

Sec. 5.—Cotton Seed Cake not coming up in analysis to that specified or implied by grade mentioned in contract shall be a good delivery if within one-fourth of one per cent of ammonia content, or one and one-quarter per cent of combined protein and fat, if sold in this way, but the settlement price shall be reduced at the rate of one-eighth of the contract price for each per cent of ammonia, or proportionately for fractions thereof of deficiency. But when sold for export the basis of contract shall be protein and fat combined, and the settlement price shall be reduced at the rate of $\frac{1}{8}$ or $\frac{1}{16}$, as the case may be, of the contract price for each one per cent of combined protein and fat, or fraction thereof, deficiency.

Where Cake is sold on sample, to be a good delivery it must reasonably conform to the sale sample in color and texture and analysis.

Sec. 6.—On contracts for Cotton Seed Cake, either loose or in sacks, shipment of 1 per cent more or less than the weights specified shall be taken as fulfillment of contract.

Sec. 7.—No claim for deficiency of protein and fat combined, or of ammonia shall be made by buyers, unless the deficiency shall exceed one-half of one unit of protein and fat combined, or one-tenth of one unit of ammonia.

Sec. 8.—Screened Cracked Cake shall be made from Cotton Seed Cake according to grade as provided and sold; shall be reasonably free from Meal, and be well prepared and screened in pieces ranging in size from that of a grain of corn to two inches in diameter, and shall be reasonably free from large pieces or slabs of Cake which cannot be fed to cattle without further preparation.

The crude pressed oil takes up coloring matter from the kernel, and may be very dark, almost black in color,

depending on the freshness of the seed. Crude oil is graded by the Interstate Cottonseed Crushers Association as follows:

COTTON SEED OIL—GRADES

RULE 4. Sec. 1.—Choice Crude Cotton Seed Oil must be made from sound decorticated Seed; must be sweet in flavor and odor, free from water and settlings, and shall produce, when properly refined, Choice Summer Yellow Oil at a loss in weight not exceeding six per cent.

Sec. 2.—Prime Crude Cotton Seed Oil, must be made from sound decorticated Seed; must be sweet in flavor and odor, free from water and settlings, and must produce Prime Summer Yellow Oil with the use of caustic soda by the official methods adopted by the Chemists' Committee, with a loss in weight not exceeding nine per cent; Provided, that any Oil that refines with a greater loss than nine per cent, but still makes Prime Summer Yellow Oil, shall not be rejected, but shall be reduced in price by a corresponding per cent of the contract price of the Oil.

Sec. 3. Off Crude Cotton Seed Oil.—Oil neither Choice nor Prime shall be called "Off Oil." When Off Oil is sold by sample, any Oil tendered shall equal sample, but if it should refine at a loss exceeding the loss of the sample by not over five per cent, but otherwise equal, it is still a good tender at a reduced price in proportion to the excess loss.

The buyer shall have the right to reject the Oil outright if it tests beyond five per cent refining loss as compared with the sale sample.

Sec. 4.—Where claim is made for excess refining loss, the value of the excess Soap Stock, less any excess cost of handling such Oil, shall be taken into consideration in settlement by the parties at interest.

Sec. 5.—Oil produced by Cold Presses or expeller process is tenderable on contracts for the above three grades when such product will refine within the requirements of this Rule, but when Cold Pressed Oil is intended to be delivered it must be so stated at time of sale.

Crude oil up to 1 per cent free fatty acids is refined for butter oil. From 1 to 2 per cent acids in the crude, produce prime yellow oil when refined. Above 2 per cent acid oil is difficult to decolorize, and is not suitable for edible purposes.

The crude oil is refined by treating with caustic

soda, which takes out most of the color, and the free fatty acids. The soap thus formed, which also contains mucilaginous matter, is called soap stock (or foots soap). The loss in weight which the crude oil undergoes in this refining is determined in the laboratory on samples, and is referred to in the above-quoted specifications as refining loss. The refining loss depends largely on the freshness of the crude oil, and usually runs from 7 to 10 per cent.

Refined oil is graded by the Interstate Association as follows:

REFINED OIL—GRADES

RULE 7. Sec 1.—Choice Summer Yellow Cotton Seed Oil must be sweet in flavor and odor, prime in color, clear and brilliant in appearance and free from moisture.

Sec. 2.—Prime Summer Yellow Cotton Seed Oil must be clear, sweet in flavor and odor, free from water and settlings, and of no deeper color than 35 yellow and 7.1 red on Lovibond's equivalent color scale.

The color scale examination shall be made as follows: The Oil is placed in a pure white four-ounce sample bottle; the depth of the Oil in the bottle shall be 5½ inches. The bottle shall be placed in a tintometer which is protected from any light except reflected white light and the reading made at a temperature of about 70 degrees Fahrenheit or by such methods as may be recommended by the United States Bureau of Standards, provided the same be approved by the Chemists' Committee and provided that the color determined shall be expressed in Lovibond terms. If the Oil is of deeper color than the glass standard 35 yellow, 7.1 red, it shall not be classed as Prime.

Sec 3.—Prime Winter Yellow Cotton Seed Oil must be brilliant, free from water and settlings, sweet in flavor and odor, and of Prime Summer Yellow color as described above, and must stand limpid at a temperature of 32 degrees Fahrenheit for five hours.

The cold test shall be made as follows: A regular four-ounce sample bottle shall be filled full of the Oil to be tested, a thermometer shall be inserted through the cork of the bottle, and hermetically sealed. The Oil shall then be heated slowly to a temperature not exceeding 80 degrees Fahrenheit, and remain at that temperature not exceeding fif-

teen minutes. It shall then be chilled until it stands at 32 degrees Fahrenheit, at which point it must stand for five hours, and must be clear, brilliant and limpid at the expiration of that time.

Sec. 4.—Good Off Summer Yellow Cotton Seed Oil may be off in flavor and / or odor, but must be prime in color and free from water and settlings and shall not contain more than $\frac{1}{4}$ of 1 per cent of free fatty acid.

Sec. 5.—Off Summer Yellow Cotton Seed Oil shall be free from water and settlings, off in flavor or odor, but of no deeper color than 35 yellow and 12 red on Lovibond's color scale and shall not contain more than $\frac{1}{4}$ of 1 per cent of free fatty acid.

Sec. 6.—Reddish Off Summer Yellow Cotton Seed Oil, designated as such, may be of inferior flavor and odor and of no deeper color than 35 yellow and 20 red on Lovibond's equivalent color scale, shall be free from water and settlings and shall not contain more than $\frac{1}{4}$ of 1 per cent of free fatty acid.

Sec. 7.—Bleachable Prime Summer Yellow Cotton Seed Oil must be clear, sweet in flavor and odor, free from water and settlings, and when bleached shall be of no deeper color than 20 yellow and 2.5 red, on Lovibond's equivalent color scale. The bleaching test shall be made by the official methods of the Chemists' Committee. The color examination shall be made in the manner provided for Summer Yellow.

Sec. 8.—Prime Summer White Cotton Seed Oil must be clear, free from water and settlings, sweet in flavor and odor, and the color of the Oil shall not be darker than the combined standard glasses, 20 yellow, 2.5 red, Lovibond's color scale.

Sec. 9.—Prime Winter White Cotton Seed Oil must be brilliant, sweet in flavor and odor, free from water and settlings, and the color of the Oil shall not be darker than the combined standard glasses, 20 yellow, 2.5 red, of Lovibond's color scale, and must stand the cold test as prescribed in Section 3.

Oil for edible purposes is bleached by fuller's earth, for technical purposes by bleaching powder, acid, etc. Deodorizing is done by superheated steam.

The grades established by the New York Produce Exchange are practically the same as those of the Interstate Cottonseed Crushers Association, both for crude and refined oils.

Soap stock is defined by the Crushers Association, as follows:

SOAP STOCK

RULE 8. Sec. 1.—Soap Stock must be a product of the refining of Crude Cotton Seed Oil, and all sales thereof, unless otherwise agreed upon by seller and buyer, are made upon a basis of 50 per cent fatty acid, not to fall below 40 per cent; if containing less than 40 per cent fatty acid, Soap Stock shall not be considered merchantable and may be rejected; delivery to be made in merchantable packages or tank cars.

Soap Stock shall be drawn for at 80 per cent of the invoice, unless analysis of the seller accompanies invoice; said analysis to be signed by the chemist; in which case draft shall be made for the amount indicated by the shipper's analysis.

Sec. 2.—Acidified Soap Stock must be a product of completely acidified Soap Stock, thoroughly settled, and all sales thereof, unless otherwise agreed upon by buyer and seller, are to be made upon a basis of 95 per cent total fatty acid, and not to fall below 85 per cent; if containing less than 85 per cent fatty acid, acidified Soap Stock shall not be considered merchantable as such, and may be rejected; deliveries to be made in merchantable packages or tank cars; when in tank cars, said cars must be equipped with steam coils.

Acidified Soap Stock shall be drawn for at 90 per cent of the invoice unless analysis of the seller accompanies invoice; said analysis to be signed by the chemist; in which case, draft shall be made for the amount indicated by the shipper's analysis.

Winter or demargarinated oil has the stearine removed by standing cold, or filtering. Such oil will not deposit further stearine. Winter oil has a lower titer test than summer oil. The stearine as obtained above is used in lard and butter substitutes, and margarine.

The best grades of cottonseed oil are used for edible purposes. It gums and dries too much to be used as a lubricating oil. It has some use as a paint oil, and for other minor purposes. A good deal of cottonseed oil is hardened by hydrogenation to form lard substitutes,

etc. The oil treated with sulphur is used as rubber substitute.

Characteristics

Specific gravity at 15.5° C.....	.923-.926
Saponification number.....	191-196
Iodine number.....	101-121
Solidifying-point.....	+4 to -1° C.
Titer.....	28-38° C.
Unsaponifiable matter.....	0.7-1.6%

Cottonseed stearine:

Specific gravity at 15.5° C.....	.918
Saponification number.....	194-195
Iodine number.....	89-104
Solidifying-point.....	16-32° C.
Titer.....	16-22

Oriental cottonseed oil varies in color all the way from light yellow to nearly black, with acid content corresponding. Most lots are less than 5 per cent in free fatty acids. No definite grades have been established. The character of importations is shown by the following table:

FREE FATTY ACIDS

	Below 1%	1-2%	2-4%	4-6%
January-June, 1918, per cent...	35	13	50	2
June-August, 1918.....	.....	.....	31	69

Sesame Oil.

From seeds of sesame plant. Grown in China, Japan, Java, E. Indies, Egypt, Brazil, Mexico. Seeds

contain 50 to 57 per cent oil, and yield 42 to 48 per cent. Press cakes used for cattle food, contain 8 to 10 per cent oil, 36 per cent proteids.

Best grades are used for edible purposes, especially in manufacture of margarine. Several European countries require a percentage of sesame oil to be mixed in butter substitutes to facilitate their detection if used to adulterate butter, as sesame is easily detected by the Baudouin color test. Also used in drugs, perfumes, soap and to adulterate almond and olive oil. It does not readily become rancid.

Characteristics

Specific gravity at 15.5° C.....	.923-.926
Saponification number.....	188-193
Iodine number.....	103-117
Solidifying-point.....	-4. to -6° C.
Titer.....	21-24
Unsatifiable matter.....	0.9-1.4%

An average of a number of analyses of importations of sesame oil at Seattle is as follows:

Free fatty acids.....	1.13%
Saponification number.....	190.3
Iodine number.....	112.2
Unsatifiable matter.....	0.7%
Specific gravity at 15.5° C.....	.9245
Titer.....	17.4° C.
Refining loss.....	6.5%

Generally the Halphen test gives no reaction for cottonseed oil. Color is medium yellow. A small amount of stearine is present at ordinary temperatures.

A good majority of the importations contain less than 1 per cent acids. Not a great deal of this oil has been handled so far through Seattle.

Rape Oil, Colza Oil

From seeds of rape of which there are several varieties. Grown in Europe, India, Japan, China.

The seed contains 33 to 45 per cent oil. Expressed seed makes good cattle food, extracted seed is used as fertilizer.

Crude oil is dark colored and has a peculiar characteristic smell, sometimes compared to that of "bed-bugs." It is refined by treatment with sulphuric acid, or by treatment with fuller's earth. Oil refined by sulphuric acid may contain more free fatty acid than the original oil, free fatty acid being formed in the refining process. It is necessary very carefully to wash out the sulphuric acid used, if the oil is to be used for lubricating purposes.

Rape oil is largely used in lubricants, both the refined oil and as blown oil.¹ Its high viscosity and slight tendency to become rancid fit it especially for this purpose. It should be an expressed oil to be used for lubricant. An extracted oil would have a low flash-point due to the small amount of solvent left in the oil. Rape oil is exceeded in viscosity by only a few oils as castor, olive, etc., outside of the drying oils which, of course, would not be suitable for lubricants.

It is used as an edible oil in Europe and India, as a wool oil, burning oil, for soft soap, steel quenching purposes and rubber substitute.

¹ See p. 112.

As rape oil is generally high priced, it is sometimes adulterated with other cheaper oils, such as linseed, cottonseed, mineral and fish oils. Allied seeds such as ravison and mustard sometimes are mixed unavoidably with rape seed. Such seed yields an inferior grade of oil. Both of the above-mentioned oils have greater drying properties than rape and have a greater tendency to gum on exposure to air.

Most oils which might be used as adulterants will either raise the iodine and saponification number, or lower the viscosity. Mineral oils would raise the unsaponifiable matter.

Characteristics

Specific gravity at 15.5° C...	.913-.917
Saponification number.....	170-179
Iodine number.....	97-106
Solidifying-point	-10 to -16° C.
Titer.....	12-20° C.
Unsaponifiable matter.....	0.5-1.5%
Viscosity, 100° F.....	230-250 sec. Saybolt
Viscosity, 100° C.....	60-70 sec. Saybolt
Viscosity, 70° F	370-465 Redwood

Oriental rape seed is chiefly grown in China. It may have ravison and mustard growing along with it. Two grades are produced: refined (sometimes called Shirashime or "water white") and crude or brown grade, sometimes called semi-refined.

The refined grade generally contains less than $\frac{1}{2}$ per cent acids, often running below 0.2 per cent. The crude grade is darker in color and contains up to 2 and 3 per cent acids. Other properties are:

Viscosity, Saybolt, at 100° F.	235-260 secs.
Viscosity, Saybolt, at 100° C.	50-70 secs.
Flash-point open cup.	500-625° F.
Pour test (solidifying).	-1 to +7° F.
Titer.	15-20° C.

Iodine number is most often between 100 and 102. Only 4 per cent of samples analyzed over a period of time had a higher iodine number than 104, and several of these were plainly adulterated.

Saponification number is rarely under 170 or over 176; with unsaponifiable up to 1.5 per cent. Specific gravity is generally between .914 and .915. Occasional samples give positive reaction in the Halphen test for cottonseed, and occasionally an oil will show admixture of mineral oil. As a rule the viscosity is higher than that called for by ordinary specifications for rape-seed oil. Also the pour test is liable to be higher.

Presence of ravigon- and mustard-seed oil is difficult to detect with certainty. Both tend to raise the iodine number and to lower the viscosity. The specific gravity of either is somewhat higher than rape.

Almond Oil

From bitter almonds generally, sometimes from sweet almonds. In southern Europe, Morocco, Syria, Persia. Bitter almonds yield more oil than sweet almonds, but the oil is practically the same.

Used in drugs and high-class soap. It is frequently adulterated.

Characteristics

Specific gravity at 15.5° C. ....	.9175-.9195
Saponification number.	188-195
Iodine number.	93-101
Solidifying-point.	-10 to -21° C.
Titer.	9-12° C.

Peanut Oil (Arachis, Earthnut, Groundnut)

Japan, China, Africa, United States, South America, W. Indies, E. Indies, India.

Decorticated nuts undergo fermentation if shipped considerable distances, and as a result do not yield edible oils, but are used for soap, lubricating, wool oil, etc. Nuts from different localities vary in their yield of oil. Whole nuts contain around 35 per cent of oil, the kernels containing 40 to 60 per cent oil. Yield of oil is 30 to 45 per cent of oil on a large scale.

Expression is carried on in two or three stages, with increasing temperature. The first cold-pressed oil gives the best grade of oil for edible purposes. Oil of second expression is of lower quality, but may still be used for edible purposes, while that of third expression is used for soap.

Press cakes are very good for cattle food, being higher in protein than any other oil cake. Cake from whole nuts contains 33 to 35 per cent proteins; from kernels only, 45 to 52 per cent, with over 1 per cent phosphoric acid. Cakes from mouldy nuts are used as fertilizer. The cake is also used for human consumption in varying forms.

The oil may be bleached nearly water white by fuller's earth or charcoal. On standing cold, peanut

oil deposits a stearin. Oil from hot pressing will do this even at ordinary temperatures.

The chief uses are for edible purposes (margarines) and soap. It is sometimes used to adulterate more expensive edible oils, such as olive oil, which it resembles very much in characteristics. It contains arachidic acid, which is comparatively easy of detection in mixture of other oils. Adulterations of peanut oil by other vegetable oils which might be used at present prices will generally raise the iodine number.

Characteristics

Specific gravity at 15.5° C.....	.9165-.926
Saponification number.....	186-196
Iodine number.....	83-105
Solidifying-point	0-10° C.
Titer	28-29° C.
Unsataponifiable matter.....	around . . 0.5%

Oriental peanut oil is graded as edible (less than 2 per cent acids), and off grade (over 2 per cent acids). Most of the importations are of edible grade. Some of the oil remains clear at ordinary temperatures, but most of it contains stearin. Color of edible grade light yellow, off grade darker. Refining loss on 1.5 per cent acid oil will run about 6 per cent, on 4 per cent acid oil nearly 9 per cent. The low acid oil bleaches with 6 per cent fuller's earth to less than 20 yellow and 3 red.

The specific gravity will often run as low as .916. The iodine number generally does not go over 100, while the titer may be as high as 30° C.

Other characteristics are:

Viscosity at 100° F., Saybolt, around 190 secs.

Pour test, 33-34° C.

Flash-point open cup about 600° F.

Grades of peanut oil suggested by New York Produce Exchange April 15, 1918, are as follows:

PEANUT OIL

SEC. 10.—Fair average quality, crude, shall be filtered, or well settled, and be obtained by pressure, not extraction. It shall be fair average quality of the season, provided, however, that the free fatty acids shall not exceed 2 per cent (calculated as oleic acid), nor moisture and impurities one-half of one per cent.

SEC. 11.—Choice crude peanut oil must be sweet in flavor and odor free from water and settlings, and shall produce, when properly refined, choice yellow oil with a loss in weight not exceeding 3 per cent. If not choice buyer may reject.

SEC. 12.—Prime crude peanut oil must be sweet in flavor and odor, and free from water and settlings, and must produce prime yellow oil with the use of caustic soda, with a loss in weight not exceeding 5 per cent; provided, that any oil that refines with a greater loss than 5 per cent, but still makes prime yellow oil, shall not be rejected, but price shall be adjusted as per rule 7, section 1.

SEC. 13. Basis Prime Crude Peanut Oil.—Crude peanut oil sold as "basis prime" cannot be rejected outright even if it does not produce prime summer yellow refined oil. In that case, however, in addition to allowance for excessive refining loss, if any, an allowance shall be given for deficiency in quality representing the difference in value between prime summer yellow refined oil and the quality produced by the crude oil delivered.

SEC. 14. Crude peanut oil, when not sold on any of the preceding grades, but when sold by sample, or, in absence of sample, by description, must conform in quality to description or sample.

If the refining loss does not exceed 3 per cent beyond that of sample or contract description, price may be adjusted under rule 7, section 1. If the refining loss does exceed 3 per cent beyond that of sample or contract description, buyer may reject.

REFINED PEANUT OIL—GRADES

SEC. 15.—Choice peanut oil must be sweet in odor and flavor, prime in color, clear and brilliant in appearance, and free from moisture, and shall not contain more than one-tenth of 1 per cent of free fatty acids.

SEC. 16.—Prime yellow peanut oil must be clear, sweet in odor and flavor, free from water and settlings, and of no deeper color than 50 yellow and 5 red on Lovibond's equivalent color scale, and shall not contain more than one-fifth of 1 per cent of free fatty acids.

SEC. 17.—Good off yellow peanut oil may be off in flavor and odor, but must be prime in color and free from water and settlings, and shall not contain more than one-fourth of 1 per cent of free fatty acids.

The following are the Interstate Crushers Association Grades:

PEANUT OIL—GRADES

RULE 19. *Sec. 1.*—Choice Crude Peanut Oil must be pressed and not extracted, from sound Peanuts, must be sweet in flavor and odor, free from water and settlings, and shall produce, when properly refined, Choice Yellow Peanut Oil with a loss in weight not exceeding 3%.

Sec. 2.—Prime Crude Peanut Oil must be pressed and not extracted from sound Peanuts, must be sweet in flavor and odor, free from water and settlings and must produce Prime Yellow Peanut Oil with the use of caustic soda by the official method adopted by the Chemists' Committee with a loss in weight not exceeding 5%; provided, that any Oil that refines with a greater loss than 5%, but still makes Prime Yellow Oil shall not be rejected, but shall be reduced in price by a corresponding per cent in the contract price of the Oil.

Sec. 3.—Off Crude Peanut Oil, neither Choice nor Prime, shall be called "Off Oil." When Off Oil is sold by sample any Oil tendered shall equal sample but if it shall refine at a loss exceeding the loss of the sample by not over 3%, but otherwise equal it, it is still a good tender at a reduced price in proportion to the excess loss. The buyer shall have the right to reject the Oil outright if it tests beyond 3% refining loss as compared with the sale sample.

Sec. 4.—Where claim is made for excess refining loss, the value of the excess Soap Stock, less any excess cost of handling such Oil shall be taken into consideration in the settlement by the parties at interest,

REFINED PEANUT OIL—GRADES

RULE 21. *Sec. 1.*—Choice Peanut Oil must be sweet in odor and flavor, prime in color, clear and brilliant in appearance and free from moisture, and shall not contain more than one-tenth of one per cent of free fatty acid.

Sec. 2.—Prime Yellow Peanut Oil must be clear, sweet in odor and flavor, free from water and settlings, and of no deeper color than fifty yellow and five red on Lovibond's equivalent color scale.

The color scale examination shall be made as follows: The Oil is placed in a pure white four-ounce bottle; the depth of the Oil in the bottle shall be five and one-fourth inches; the bottle shall be placed in a tintometer which is protected from any light except reflected white light, and the reading made at a temperature of about 70 degree F., or by such method as may be recommended by the United States Bureau of Standards, provided the same be approved by the Chemists' Committee, and provided that the color determined shall be expressed in Lovibond's terms. If the Oil is of deeper color than the combination standard of fifty yellow, five red, it shall not be classed as Prime.

Sec. 3.—Good Off Yellow Peanut Oil may be off in flavor and odor but must be prime in color and free from water and settlings, and shall not contain more than one-fourth of one per cent of free fatty acids.

Character of importations at Seattle is shown in the following table:

FREE FATTY ACIDS

	.25-.50 Per Cent.	.5-1.0 Per Cent.	1-2 Per Cent.	2-4 Per Cent.	4-6 Per Cent.	6-10 Per Cent.	Over 10 Per Cent.
Jan. to June, 1918, per cent.	48	26	15	5	3	3	
June to Aug., 1918, per cent.	under 1	63	30	3	2	....	2

	WATER		INSOLUBLE MATTER	
	0-.5 Per Cent.	.5-1.0 Per Cent.	0-.2 Per Cent.	.2-.5 Per Cent.
Jan. to June, 1918, per cent.	91	9	90	10
June to Aug., 1918, per cent.	100	.....	.....	Under 0.5 100

Importations of peanut oil are next in importance to soya at Seattle. Its use as an edible oil in the United States is fast increasing.

Tea Seed Oil

From the seeds of a shrub related to the tea plant (not from the tea plant cultivated for its leaves), expressed on large scale in China. Expressed oil contains saponin, which renders it dangerous for edible purposes, although it is so used in China. Extracted oil is free from saponin. Allied to this oil are Tsubaki oil and Sasanqua oil, Japanese oils which are used as hair oils and for lubricating delicate machinery.

Characteristics

Specific gravity at 15.5° C.....	.917-.927
Solidifying-point	-5 to -12° C.
Saponification number.....	188-196
Iodine number.....	89-94

Importations of this oil have not been important as yet.

Olive Oil

From the fruit of the olive tree. Western Asia, Southern Europe, Northern Africa, California, S. Africa, Australia.

Ripe fruit contains 40 to 60 per cent oil. Fruits vary considerably in their yield of oil, some districts of California yielding much lower than these amounts, as low as 10 per cent. Best oil comes from fruit not quite ripe. Quality of oil varies considerably, depend-

ing on care with which fruit is picked and handled, age of fruit, storage before pressing.

Best grades of "virgin" oil are obtained from hand-picked fruits, by peeling and removing the kernels and then light pressing. The second pressing cold will give edible oil of somewhat lower grade. Technical grades are made from later pressings hot, the "marc" (corresponding to press cake) going through a number of treatments before the last oil is extracted by solvents, usually carbon bisulphide.

The cake becomes rancid very rapidly, and is only used locally for cattle food. The extracted cake is used for fertilizer.

The crude oil is washed with water and filtered, and then any stearine is allowed to settle out. Best grades will remain clear at 10° C. The color varies from water white to yellow and green. Olive oil is valued largely on taste, which varies according to the district and treatment. Free fatty acids in good oil are less than 0.5 per cent.

The chief use is for edible purposes, as salad oil, etc. Sardines are largely put up in olive oil. Other uses for lower grade oils are for burning, soap, lubrication, wool oil, special soaps for textile uses, as for silk, calico, wool, etc., leather. Olive oil has a higher viscosity than rape, and less tendency to gum, hence is a very desirable lubricating oil. Some lower grades of oil have large amounts of free fatty acids. These are used for soap, wool oils, and in dyeing.

Characteristics

Specific gravity at 15.5° C. ....	.915-.920
Saponification number.....	185-203
Iodine number.....	77-95
Solidifying-point.....	2-10°C.
Viscosity 70° F. (Redwood).....	312 sec.
Unsaponifiable matter..... up to	3.3%
Titer.....	17-26° C.

Olive oil is quite often adulterated, sometimes very cleverly. In order to detect adulteration by analysis, it is often necessary to know the district from which the oil originated, as oils from different districts vary considerably in their characteristics.

Grades of the New York Produce Exchange for technical oil are as follows:

OLIVE OIL

SEC. 23.—Olive Oil for manufacturing purposes, commonly known as the commercial grade, shall not contain over 2 per cent of moisture and or sediment, and not exceed 7 per cent of free fatty acids.

If sold as yellow, must be yellow or slightly green, and not red.

If sold as green must be green in color and not turn brown when saponified with the solution of 20 deg. Baumé caustic soda in the proportion of 8 c.c. to 10 grams of oil, hot.

Castor Oil

From the beans of the castor plant. Grown in India, Java, China, Japan, Mexico, United States, Mediterranean, S. America.

Beans contain 45 to 55 per cent oil and yield about 40 per cent.

Best quality of oil for medicinal purposes is obtained from the first cold pressing. Two later expressions are made which give technical grade of oil. The press

cakes contain a poisonous alkaloid "ricine," which renders them unfit for use as cattle food, but they are used as fertilizer. Some castor is extracted by solvents after the last pressing, as the press cakes after final pressing still contain almost 8 per cent oil. Inferior seeds are also extracted instead of being pressed.

Refining is done by steaming the oil. Albuminous matter is thereby coagulated and filtered out. Properly refined oil is very slow to turn rancid. The color varies from almost colorless to yellow. Some crude varieties are green.

Stearine deposits on standing cold. Castor oil has the highest gravity and viscosity of any fatty oil. It also differs from other oils in its solubility in alcohol, and its insolubility in petroleum ether. These properties are made use of to detect adulterants in castor. Castor oil will not mix with mineral oil. If a third oil, however, is present as rape, lard, etc., a clear mixture of the three is obtained.

Castor oil is used in medicine, for Turkey red oils used in dyeing, transparent soap, lubrication, leather industry, fly paper. Large amounts are used in internal lubrication of aeroplane engines.

The British Pharmacopeia limits medicinal oil to 2 per cent free fatty acids.

United States Pharmacopeia specifications are: .

Specific gravity.....	.958-.970
Saponification number.....	177-187
Iodine number.....	83-90
Acid number.....	not over 4.0 ¹
Refractive index 40° C.....	1.4695-1.4730
Soluble in 3.5 parts 90 per cent alcohol	

¹ Free fatty acids, 2.0 per cent.

Turkey red oil is formed by treating castor with sulphuric acid, that is, it is a sulphonated oil. Similar products called olive and cottonseed Turkey red oils are made by treating these other oils. The treated oil is used in the preparation of calico before dyeing or printing with alizarin colors. It is valued by the amount of fatty matter contained which varies from 40 to 65 per cent.

Characteristics

Specific gravity at 15.5° C. ....	.959-.968
Saponification number.	177-187
Iodine number.	81-91
Solidifying-point.	-10 to -18° C.
Acetyl number.	145-155
Viscosity, 100° F., Saybolt.	1400-1430 secs.

Soluble in all proportions in absolute alcohol. At 15° C. one volume oil dissolves in two volumes of 90 per cent alcohol. At 17.5° C. one volume dissolves in five volumes alcohol of 0.829 specific gravity.¹ Turbidity shows presence of foreign oils. As little as $\frac{1}{4}$ per cent of foreign oil may be thus detected. It is miscible in an equal volume of petroleum ether. Any excess of this amount is not miscible.

The solubility tests give a quick way of estimating adulterations. Any foreign oil will lower the specific gravity and viscosity of castor and would generally raise the iodine and saponification numbers. The acetyl number is a valuable characteristic also in determining the purity, as any other oil would lower the acetyl number.

¹ Sometimes called Finkener's test.

Oriental castor oil contains from 1 to 6 per cent or more free fatty acids. Color varies from very light yellow to green. Specific gravity from .960 to .965. A considerable portion of it shows adulteration with some other oil, but this is generally less than 5 per cent and must be considered accidental.

The viscosity of Oriental castor oils at 15° C. varies from 6500 to 7400 seconds on the Saybolt instrument, at 100° C. from 97 to 99 seconds. The lower viscosities are those of oils containing around 7 or 8 per cent free fatty acids and up to 5 per cent of other oils than castor. Flash-points (open cup) range from 495° to 540° F., the lower one being high acid oils. All samples tested have had a pour test of some degrees below 0° F.

The character of importations at Seattle is seen from the following tables:

FREE FATTY ACIDS

	1-2 Per Cent.	2-4 Per Cent.	4-6 Per Cent.	6-10 Per Cent.
January to June, 1918, per cent.	29	48	10	13
June to August, 1918, per cent..	23	55	19	3

WATER

0-.5%	.5-1.0%	1-2%
59%	35%	6%

About 90 per cent of the oil is clear, balance turbid or cloudy, irrespective of whether it contains water or not.

Castor beans are mostly cultivated in a small way in China and Manchuria, and the beans may become admixed with other beans. The refined grade undergoes a partial purification. It is generally handled in small batches in the mills.

United States Army Signal Corps Specification No. 3500-A for Castor Oil for Aircraft Engine Lubrication, is as follows:

GENERAL.

1. This specification is drawn to cover the requirements of the Signal Corps in all purchases of castor oil for rotary engine lubrication. The oil must be a high-grade vegetable castor oil suitable for this purpose. Both cold-pressed vegetable castor oil and hot-pressed vegetable castor oil which has been refined so that it will meet the requirements of this specification may be submitted for purchase.

2. The castor oil must be free from adulteration, other oils, suspended matter, grit and water.

PHYSICAL PROPERTIES AND TESTS.

3. The castor oil must meet the following requirements:

4. *Color*.—When observed in a 4-oz. sample bottle, the castor oil must be colorless or nearly so, transparent, and without fluorescence.

5. *Specific Gravity*.—The castor oil must have a specific gravity of 0.950 to 0.968 at 60 deg. F. (Baumé gravity must be from 16.05 to 14.70 at 60 deg. F.).

6. *Solubility*.—The castor oil must be completely soluble in four (4) volumes of ninety (90) per cent alcohol (specific gravity 0.834 at 60 deg. F.). This test shall be made on a 2 c.c. sample.

7. *Acid Number*.—It must not require more than three (3) milligrams of potassium hydroxide (KOH) or 2.14 milligrams of sodium hydroxide (NaOH) to neutralize one (1) gram of oil. This is equivalent to 1.5 per cent oleic acid.

8. The test for acidity shall be made on samples weighing five (5) to ten (10) grams. Samples shall be heated for one-half ($\frac{1}{2}$) hour with fifty (50) c.c. of neutral alcohol and then titrated with fifth normal ($\frac{N}{5}$) sodium or potassium hydroxide, using phenolphthalein as an indicator.

9. *Iodine Number*.—(Hanus method). The iodine number must be between 80 and 90. Samples used for this test shall weigh 0.2 to 0.25 gram and shall be treated for one (1) hour.

10. *Saponification Number*.—The saponification number must be between 176 and 187.

11. This test shall be made on samples weighing two (2) to three (3) grams. Samples shall be saponified with half normal $\left(\frac{N}{2}\right)$ alcoholic sodium or potassium hydroxide for one (1) hour and shaken at least five (5) times. Titrate with fifth normal $\left(\frac{N}{5}\right)$ acid, using phenolphthalein as an indicator.

12. *Unsaponifiable Matter*.—The unsaponifiable matter must not exceed one (1) per cent. Samples used for this test shall weigh five (5) to ten (10) grams.

13. *Rosin*.—(Lieberman-Storch test). The castor oil must not give a reaction for either rosin or rosin oil.

14. *Cotton Seed Oil*.—(Halphen test). The castor oil must not give a reaction for cotton seed oil.

15. This test shall be made on samples measuring one (1) to three (3) c.c. Dissolve the oil in an equal volume of amyl alcohol, and then add a volume of Halphen reagent (1 per cent solution of sulphur in carbon bisulphide) equal to the volume of oil used.

16. *Viscosity*.—The castor oil when tested in a Saybolt Universal Viscosimeter must have a viscosity of not less than 450 seconds at 130 deg. F. and 95 seconds at 212 deg. F.

17. *Flash-point*.—The flash-point must not be less than 450 deg. F. in a Cleveland open flash cup.

18. *Cold Test*.—The castor oil, in a 4-oz. sample bottle one-quarter ($\frac{1}{4}$) full, must not congeal at a temperature of zero deg. F. The thermometer bulb shall be inserted in the oil during the test.

SAMPLING, ANALYSIS AND INSPECTION

19. The inspector shall take a sufficient number of samples to fairly represent each lot of oil submitted. In case of doubt as to the proper method of sampling, instructions may be obtained from the Equipment Division Laboratory of the Signal Corps.

20. Individual test samples shall not be smaller than eight (8) fluid ounces. Samples on which check analyses are to be made, as provided in paragraph 22, shall not be smaller than sixteen (16) fluid ounces.

21. The Seller shall furnish, at his own expense, the necessary samples

and make the analyses and tests required by this specification. The Seller shall furnish a report of all tests and analyses to the inspector.

22. As a check upon the analyses made by the Seller, the inspector shall select a certain number of samples and send them to the Equipment Division Laboratory for test.

23. When a check analysis is required the inspector shall divide one of the samples provided for in paragraph 20 into two (2) equal parts. One part shall be the Seller's sample and the other part shall be sent to the Equipment Division Laboratory, Bureau of Standards, Washington, D. C. The inspector shall mark such samples clearly with the name and address of the Seller, the date, the Signal Corps order number and any additional information helpful in identifying the lot of oil which the sample represents. Check analyses shall be made without cost to the Seller.

Communications regarding all technical matters pertaining to specifications should be addressed to the Specification Section, Signal Corps, U. S. Army, Washington, D. C.

Animal Oils

Divided into two classes:

- (1) Marine animal oils.
- (2) Terrestrial animal oils.

The marine animal oils absorb oxygen and correspond to the vegetable drying oils; while terrestrial animal oils are mostly non-drying.

Marine animal oils are further subdivided into:

- (a) Fish.
- (b) Liver oils.
- (c) Blubber oils.

Fish Oils

Obtained from all parts of common fish. The *bodies* of fish yielding liver oil contain only small amounts of oil as a rule, while the *livers* of the fish from which body oil is obtained yield only small amounts of liver oil.

Fish oils are characterized by a special odor. They are usually darker colored than vegetable oil. The

color and smell depend largely on the condition of the fish as regards putrefaction, before the oil is obtained. The oil is usually obtained by rendering with water or steam and separating the oil. Many attempts have been made to deodorize fish oils. It is stated that at present fish oils are being used in Scandinavian countries for edible purposes.

The residue, after extraction of the oil, is a valuable fertilizer. It is dried and ground and sold as fish scrap or fish waste. It is also used in poultry food.

On standing most fish oils deposit stearine. They absorb oxygen from the air and "dry" like linseed oil, the skin formed being somewhat sticky. They are sometimes used to adulterate linseed and other drying oils, but the admixture of fish can be detected by special methods of examination. Most of the fish oils are used in the leather industry.

Menhaden Oil

Menhaden is caught off the Atlantic Coast of the United States from April till November. The fish have been used by farmers for a long time as fertilizer. Now the oil is recovered by rendering or pressing and the waste is dried and sold as fertilizer.

Oil from fresh fish is light colored, but the longer the fish are kept before obtaining the oil, the darker will be the color of the oil. Four grades are: *A*, extra pale; *B*, pale; *C*, brown; *D*, dark brown. The southern oil contains more stearine, which separates out on standing cold. Winter oils are obtained by standing for some time in the cold, and then separating the deposited stearine.

The oil is refined by filtering, giving strained oil, and also by bleaching with fuller's earth, etc., giving bleached oils, yellow and white.

It is used principally in currying leather, for making sod oil,¹ in soap making, tempering steel, rubber substitute, waterproofing, in paint oils, linoleum, etc. Sometimes cod liver oil is adulterated with it.

Characteristics

Specific gravity at 15.5° C.....	.928-.931
Saponification number.....	188-193
Iodine number.....	139-193
Unsaponifiable matter.....	0.6-2.1%
Solidifying-point.....	-4° C.

Japanese Sardine Oil, or Fish Oil

Obtained in Japan principally from a fish belonging to the sardine family, but is also liable to have other fish oils admixed.

The crude oil contains 30 per cent stearine. This is sold as "fish tallow" and is used in currying leather.

Color ranges from light yellow to very dark red. The oil is used in the soap and leather industries.

Owing to other fish oils being admixed, the characteristics of this oil as it comes on the market, vary widely.

Characteristics

Specific gravity at 15.5° C.....	.915-.934
Saponification number.....	179-196
Iodine number.....	104-187
Unsaponifiable matter.....	.5-2.3
Titer.....	28° C.

¹ See p. 118.

Japanese oil is graded thus:

No. 1, up to 6 per cent free fatty acids.

No. 2, 6 to 8 per cent.

No. 3, over 8 per cent.

The character of these grades is shown by the following averages of a number of samples analyzed in the author's laboratory:

	No. 1.	No. 2.	No. 3.
Free fatty acids, per cent. . . .	5.0	7.0	8.5
Saponification number.	190	188	190
Iodine number.	162	145	94
Unsatifiable matter, %	0.45	0.4	0.65
Specific gravity at 15.5° C. . .	.9269	.9247	.9283
Titer, deg. C.	25.3	22.8	24.9
Color.	Brown	Reddish br'n	Darker brown
Stearine at 60° F.	Small	Small	Small

Sardine Oil

From heads and other waste of sardines in canning, in Spain and France.

Used in leather and soap industries.

Salmon Oil

A by-product of salmon canning on the Pacific Coast, Fish waste from canneries is gathered and brought to plants, where the oil is obtained, the refuse being dried and used as fertilizer. Some oil is extracted by gasoline. This gives a very dark colored oil, which so far has not been bleached. Several per cent of the solvent is generally left in the oil.

The color ranges from yellow to dark brown, depending on freshness of oil.

It is used in leather and soap.

This oil is graded as follows:

No. 1, up to 5 per cent free fatty acids.

No. 2, from 5 to 7 per cent free fatty acids.

No. 3, from 7 to 15 per cent free fatty acids.

A typical analysis of No. 1 grade is as follows:

Free fatty acids..... 3.1%

Saponification number..... 185

Iodine number..... 133

Unsaponifiable matter..... 0.76%

Titer..... 20° C.

Color..... Reddish-brown

Stearine at 60° F..... None

Herring Oil

From Japan, Scandinavia, etc.

Japanese oils deposit stearine. Color ranges from yellow to dark brown. Used in leather industry.

Japanese herring oil is graded as follows:

No. 1, up to 6 per cent free fatty acids.

No. 2, 6 to 8 per cent free fatty acids.

No 3, over 8 per cent.

Characteristics are shown by the following table of average analyses made in author's laboratory:

	No. 1.	No. 2.	No. 3.
Free fatty acids, per cent....	5.5	7.5	11.7
Saponification number.....	187	189	187
Iodine number.....	150	155	144
Unsaponifiable matter per cent	0.43	0.87	0.84
Titer, deg. C.....	24.7	24.3	25.2
Stearine.....	Small	Small	Small
Color.....	Red	Red-brown	Dark-Red

Japanese Fish Oil

Common grade contains 12 to 14 per cent acids. This is a name for fish oils imported from Japan which may comprise fish oils which do not fit in any other classification. Consequently the characteristics may vary considerably. So-called *B*-grade contains above 14 per cent acid.

The following is an analysis of a composite sample representing a number of shipments sampled at Seattle:

Free fatty acids.....	8.2%
Saponification number.....	189
Iodine number.....	155
Unsaponifiable matter.....	0.73%
Titer.....	24.5° C.
Color.....	Brown
Stearine and foots.....	Considerable

LIVER OILS

Obtained from livers of certain fish as whiting, trout, sawfish, ling, tunny, ray, hake, eel, cod, shark, dogfish, skate and haddock. As a rule the bodies of these fish do not yield oil in any amount. Liver oils in general have larger amounts of unsaponifiable matter (cholesterol) than fish body oils.

Cod Liver Oil

From livers of the cod, Newfoundland, Norway, Japan, Pacific Coast.

Best medicinal oil is prepared from fresh livers, and kept away from action of light and air. The livers decompose easily, and great care is necessary to produce best grades. Color varies from pale yellow to brown.

Lower grades of oil are used in the leather industry, but a low acid oil is desirable even here.

The oil settles out stearine on standing. Oils free from stearine are called raked oils. Dark tank cod oil from Newfoundland contains around 14 per cent acids.

For characteristics see page 80.

The British Pharmacopœia limits acids to 1.25 per cent. The United States Pharmacopœia says the oil shall be "only slightly acid to litmus paper." The complete specifications are as follows:

	U. S. Pharm.	British Pharm.
Specific gravity.....	918-.922 at 25° C.	.920-.930
Saponification number.	180-190	179-192
Iodine number.....	140-180	155-173
Color.....	Pale yellow.....	Pale yellow
Odor and taste.....	Slightly fishy not rancid	Same.
Unsaponifiable matter.	.....	Not over 1.5%
Exposed 3 hrs. to 0° C.	.....	No solid fat separating

Most of the Japanese cod oil imported at Seattle is low acid oil, much of it containing less than 2 per cent acids. It is graded as No. 1, with less than 5 per cent acids, No. 2 from 5 to 7 per cent.

Average of a number of analyses of No. 1 grade are as follows:

Free fatty acids.....	4.4%
Saponification number.....	177
Iodine number.....	151
Unsaponifiable matter.....	1.18%
Titer.....	20.9° C.
Stearine.....	Small
Color.....	Yellow-brown

Shark Liver Oil

Iceland, Japan, Pacific Coast.

Used in leather, oiled cloth, rubber substitute, often in cod liver oil as adulterant.

For characteristics see page 80.

Character of Seattle imports of Japanese No. 1 shark oil is as follows:

57% contains less than 1% free fatty acids.

20% contains from 1 to 2% free fatty acids.

23% contains from 2 to 4% free fatty acids.

The oil is graded as No. 1, up to 5 per cent acids; No. 2 from 5 to 7 per cent acids. Most of the oil on this market is of No. 1 grade, and very low in acids. Average analyses of this grade are as follows:

Free fatty acids per cent.....	1.9	2.5
Saponification number.....	170	169
Iodine number.....	130	132
Unsaponifiable matter per cent.....	1.72	2.95
Titer, deg. C.....	23.2	22.8
Stearine at 60° F.....	Small	None
Color.....	Yellow	Reddish-yellow

Dogfish Liver Oil

Washington, British Columbia, and Oregon Coasts. Sometimes mixed with cod oil. Bodies of fish are dried and sold as fertilizer, dogfish scrap. It is high in nitrogen. Attempts have been made lately to use the dogfish for food, under the name of grayfish. Its preservation is difficult.

Character of oil produced is shown by the following:

FREE FATTY ACIDS

	Under 1 Per Cent.	1-2 Per Cent.	6-8 Per Cent.
June to August, 1918, per cent.	50	25	25

The oil is graded as No. 1, under 2 per cent acids; No. 2, from 2 to 5 per cent acids. Analyses of a number of samples of No. 1 and No. 2 grades are as follows:

	No. 1.	No. 2. ^a
Free fatty acids per cent.	1.10	3.45
Saponification number.	155	165
Iodine number.	112	128
Unsaponifiable matter per cent.	1.62	2.35
Titer, deg. C.	22.7	22.9
Stearine at 60° F.	Small	Small
Color.	Reddish-yellow	Light brown

Livers of coalfish, haddock, whiting, hake, skate and ling are also used for oil. Often mixed with cod oil. Presence of these in cod oil cannot be detected.

Characteristics of Liver Oils

As given by standard text.

	Cod.	Shark.	Dogfish.
Specific gravity at 15.5° C. . . . .	.922-.941	.910-.928	.918-.930
Saponification number.	168-190	140-197	170-225
Iodine number.	135-198	111-155	126-154
Solidifying-point, deg. C.	0 to -10		
Titer, deg. C.	13-24		
Unsaponifiable matter % . . . . .	.6-4.6	1.0-22.0	1.0-9.0

BLUBBER OILS

Obtained from the blubber (or fat) of number of marine animals, including seal, whale, turtle, dugong, dolphin, porpoise and brown fish. Last three, as well as sperm whale oil, contain spermæceti.

Whale Oil

A number of species of whale yield oil. The whales nowadays are generally brought to a "whaling station" where the carcass is worked up. The character of the oil obtained depends on the time that it takes the whale to reach the station, and on the temperature of the water.

The yield of various whales is given as follows by Lewkowitsch:

		Yield in Gallons.
Right.....	Pacific.....	750-7600
Right.....	Atlantic.....	750-4500
Bowhead.....	.....	900-7600
Humpback.....	Pacific.....	300-3400
Humpback.....	Atlantic.....	300-3100
Finback.....	Pacific.....	300-2100
Finback.....	Atlantic.....	600-1900
Sulphur bottom.....	.....	1500

The oil is extracted by rendering and pressing. The meat is dried and sold as fertilizer. The bones are ground and also sold as fertilizer.

Whale meat, when fresh, is sold for edible purposes. It resembles beef, and has no objectionable taste.

Train oil is an old name for northern whale oil, but is also used to include all blubber oils.

Grades of whale oil are Nos. 1, 2, 3, 4. No. 1 is pale yellow in color and has a faint fishy smell. Nos. 2, 3 and 4 are correspondingly darker and stronger in smell. All grades deposit large amounts of stearine on standing. This is sold as whale tallow or stearine, for soap making and lubricants. The above grades vary considerably, in their qualities, depending on their source. Common Pacific Coast practice is as follows:

- No. 1, up to 2 per cent free fatty acid.
- No. 2, from 2 to 5 per cent free fatty acid.
- No. 3, from 5 to 15 per cent free fatty acid.
- No. 4, above 15 per cent free fatty acid.

No. 1 oil is made from blubber only. Nos. 2, 3 and 4 from flesh, bones, etc. No. 2 being generally from flesh and residue of No. 1, while 3 contains bone oil, and 4 is the oil from decomposed flesh. Considerable water is sometimes found with the lower grades of oil. European practice recognizes a No. 0 grade, containing up to 1 per cent acids. This is simply a choice grade of our No. 1.

The pale grades of oil are used for burning and soap, lower grades for leather, also as "batching" oil for jute, for steel tempering, as lubricant on lathes, etc., sheep dip.

Hydrogenated oil is used for edible purposes and soap.

Characteristics

Specific gravity at 15.5° C. ....	.917-.927
Saponification number.	184-194
Iodine number.	110-146
Titer.	23-24° C.
Unsaponifiable matter.	0.6-3.7%

Flash-point (No. 1)	570° F.
Flash-point (No. 3)	380° F.
Viscosity (No. 1), 100° F. (Saybolt)	166 sec.

Analyses of composite samples of domestic grades of whale oil made in author's laboratory are as follows:

	No. 1.	No. 3.	No. 4.
Free fatty acids, per cent.	0.85	9.38	35.0
Saponification number	184	192	183
Iodine number	109	106	124
Unsaponifiable matter, per cent	1.06	1.02	1.67
Titer, deg. C.	23.3	27.3	22.4
Stearine	Much	Much	Much
Color	Nearly white	Brown	Dark brown

One grade of Japanese whale oil is imported at Seattle, called No. 1, acids below 3 per cent.

Composite analysis is as follows:

Free fatty acids	1.13%
Saponification number	190
Iodine number	120
Unsaponifiable matter	0.95%
Titer	21.7° C.
Stearine	Much
Color	Light brown

Turtle Oil

From body fat of species of turtle.

Characteristics

Specific gravity at 15.5° C. . . . .	.919-.933
Saponification number	193-211
Iodine number	111-127
Solidifying-point	10-20° C.

A sample from Hawaiian Islands contained 0.14 per cent free fatty acids and 0.78 per cent unsaponifiable matter.

Porpoise Oil

Body oil is intermediate between blubber oils and liquid waxes such as sperm oil. It contains up to 4 per cent unsaponifiable matter.

The jaw oil of both the porpoise and dolphin is used for lubricating fine machinery, such as watches. It contains up to 16 per cent unsaponifiable matter.

Characteristics

	Body	Jaw.
Specific gravity.....	.925-.937	.926
Saponification number....	195	253-272
Iodine number.....	88-119	21- 77
Unsaponifiable, per cent...	.7-3.7	Up to 16.0
Solidifying-point, deg. C...	-16	
Volatile acids, per cent....	23-40	47-65

Dolphin Oil

Both body and jaw oil are similar in characteristics to porpoise body and jaw oil respectively, and are similarly used.

TERRESTRIAL ANIMAL OILS

Silkworm Oil, Chrysalis Oil

Obtained by extraction of chrysalis of silk worm. Has dark color, very bad smell, high in acids, some as high as 50 per cent. Contains up to 10 per cent unsapon-

ifiable matter. May also be prepared by steaming and pressing.

Importations so far have been unimportant.

Characteristics

Specific gravity at 15.5° C.....	.91-.93
Saponification number.....	190-194
Iodine number.....	116-132
Solidifying-point.....	7-10° C.

Egg Oil

From hard-boiled hen eggs, by pressure or solvents. Used for tanning leather.

Characteristics

Specific gravity at 15.5° C.....	.914
Saponification number.....	185-190
Iodine number.....	68-82
Solidifying-point.....	8-10° C.

Neat's-foot Oil

From the feet of cattle. By-product of slaughter houses. Obtained by boiling and skimming. The shin bones yield the genuine neat's-foot oil, but in the United States the feet are generally used with the shin bones. The fat of the marrow is kept separate.

Feet of sheep and horses are sometimes mixed. Also the oil may be adulterated with bone oil, and other foreign oils, fish and vegetable oils being used for this purpose. Most of the latter can be readily detected.

The oil is valued on its smell, color, low-freezing-point and acidity. In its use in leather a low freezing-point is specially desirable. It is used largely in dressing leather. Also for lubricant of fine machinery.

Characteristics

Specific gravity at 15.5° C...	.915-.9175
Saponification number.....	194-199
Iodine number.....	66-76
Solidifying-point.....	- 3 to -10° C.
Titer.....	16-26° C.
Unsaponifiable matter.....	.1-.65%

The oil is graded commercially on the cold test, e.g., 20°, 40° oil. These are the temperatures in degrees Fahrenheit at which stearin settles out. Most adulterants will raise the iodine value, or can be detected by examination of the unsaponifiable matter.

Palm Oil

From outside fleshy part of the palm tree. West coast of Africa, Philippines. A South American palm yields much smaller amounts of oil. This oil is different from palm nut oil, which comes from the kernels. West coast of Africa is the important source.

The oil is prepared mostly by natives in various crude fashions. They then bring it oftentimes long distances to the coast where it is collected by traders, and starts on its way to the final markets. The quality depends on the care with which it has been handled. It is said that the natives only obtain about one-third of the total oil extractable.

The oil is used by the natives for cooking, when fresh. It has a sweetish taste and pleasant odor resembling violets, which persists even after it has been made into soap. When leaving the coast of Africa it has 10 to 15 per cent free acids, but on arrival at destination

these have increased to 20 to 50 per cent. Free glycerin is present in such oil. "Soft" oils are the low acid oils, while "hard" oils are high in acids. Consistency varies from that of soft butter to tallow, color dark yellow to red. It is bleached by chemical processes. Some red oils resist bleaching.

It is used for soap and candles, also to coat iron sheets before tin plating. Palm oil grease used in the tin plate industry has cottonseed and mineral oil admixed. It is also used in lubricants, as railway axle grease, and in coloring butter substitutes. For lubricating, the free acid must be neutralized. The crude oil is sometimes adulterated by mixing with earth, and also generally contains water.

Characteristics

Specific gravity at 15.5° C.....	.920-.924
Saponification number.....	196-205
Iodine number.....	53-58
Solidifying-point.....	31-39° C.
Titer.....	41-49° C.

In the candle industry palm oil is valued on the titer test.

New York Produce Exchange rules that "palm oil shall be sold upon designations of the districts of origin, allowance to be made for dirt and water in excess of 2 per cent."

Cacao Butter

From cacao beans or seeds of cacao tree. West Indies, Central and South America, West Africa.

By-products of cocoa and chocolate industry. (Must

not be confused with cocoanut oil, which comes from an entirely different tree.)

Beans are first roasted, and shells removed. Shells contain 3 to 6 per cent fat, which is sometimes recovered as cacao shell butter. Otherwise the shells are used as cattle food.

Kernels are ground and pressed hot. Alkali carbonates are added before pressing, so that the fat as obtained is free from acids. A certain amount of fat must be left in the press residue, from which cocoa, etc., is prepared.

Cacao butter is white, has a chocolate smell, and is somewhat brittle at ordinary temperatures. It is often adulterated by so-called "chocolate fat" made from cocoanut or palm nut oil stearine. It is used in manufacture of chocolate, confectionery, pharmacy and perfumes.

Characteristics

Specific gravity at 15.5° C. ....	.964-.976
Saponification number.	191-202
Iodine number.	32-42
Solidifying-point.	21-26° C.
Melting-point.	28-33° C.
Titer.	48-49° C.

Chinese Vegetable Tallow

This is the hard fat, coating the seeds of the Chinese tallow tree. The kernels contain *Stillingia* oil. The best vegetable tallow is prepared with precaution not to obtain any of the oil admixed, as admixture of the oil makes the tallow of lower melting-point and softer.

When the whole crushed seed is used in preparation, the product contains the oil, and is much softer. The pure tallow, with no admixture of oil, will not leave a grease spot on paper. Most of it is shipped out from Hankow, where it is purified. It is cast in blocks for shipment. Used in soap and candles.

Characteristics

Specific gravity at 15.5° C.....	.915-.918
Saponification number.....	179-231
Iodine number.....	19-38
Solidifying-point.....	24-32° C.
Melting-point.....	36-53° C.
Titer.....	40-56° C.

Palm Nut Oil, Palm Kernel Oil

From the kernels of the fruit of the palm in West Africa. The kernels are expressed hot and yield 40 to 45 per cent oil. Pressed cake has little value. Oil is used for soap making. This oil, like cocoanut, will make soap by the cold process. It is also used in chocolate fats, butter substitutes. Well refined palm nut oil is said to have as good keeping qualities as cocoanut.

Characteristics

Specific gravity at 40° C.....	.912
Saponification number.....	242-254
Iodine number.....	10-17
Solidifying-point.....	23-24° C.
Melting-point.....	23-30° C.
Titer.....	20-25° C.
Volatile acids (Reichert-Meissl) ¹ ...	5-8%

¹ See p. 20.

Cocoanut Oil

Obtained from kernels of cocoanut, which grow in the coast regions of practically all tropical countries. Principal territories are Ceylon, India, Java, Straits Settlements, Pacific South Sea Islands and South America.

Kernel contains 30 to 40 per cent fat and about 50 per cent moisture.

The oil has been extracted by the natives for a long time. Various crude methods are in use, as sun-drying, drying over a fire, or boiling in water and skimming off the oil. The latter process is used in Cochin, and gives the best grade of oil. If the kernels are not dried they soon get rancid. They must, therefore, be dried if they are to be shipped any distance. The dried product is called "copra." The quality of copra depends largely on how it has been dried. Drying by hot air gives the best grade. Next best is sun-dried, and the lowest grade is kiln-dried or smoke-dried. This is dark colored, and often contains excess moisture. If the moisture is below 4 to 6 per cent, mold does not form on it, but copra with higher percentage of water (especially above 10 per cent) becomes moldy, with a consequent rancidity of the oil and an actual loss of oil up to 25 per cent. Copra is graded according to origin and method of drying.

It will contain from 50 to 75 per cent oil and may contain up to 30 per cent water.

The grades under which cocoanut oil is sold are Cochin, Ceylon and Copra oil.

Cochin oil, the best grade, was made originally on the Malabar Coast by boiling and skimming fresh

nuts. The name now is used for best grade oil, no matter where it is produced, providing, of course, the quality is right. Cochin grade contains less than 3 per cent free fatty acids ordinarily.

Ceylon is the name applied to the second grade of oil. This oil has not been handled with as much care as Cochin grade, consequently the acids are higher, averaging around 5 per cent. Ceylon oil may originate from any port, as Manila, Singapore, Java, Japan, etc.

Copra oil is the poorest grade of cocoanut. It is expressed from the dried copra, which oftentimes has been shipped long distances before being expressed. The quality of the oil will depend largely on the degree of drying the copra has received. In order to yield a good oil copra has to be very carefully prepared.

Grades of New York Produce Exchange are as follows:

COCOANUT OIL—GRADES

SEC. 18.—Prime Crude cocoanut oil shall not contain more than 6 per cent of free fatty acids (calculated as oleic acid), and shall be free from moisture and impurities, and shall have color not deeper than 30 yellow and 5 red, provided that any oil that tests more than 5 per cent of free fatty acids (calculated as oleic acid), shall not be rejected, but shall be reduced one-half of one per cent in the contract price for each 1 per cent excess of acidity over the maximum established; and provided also, that if the color be deeper than 30 yellow and 5 red, adjustment shall be made in accordance with rule 7, section 2.

SEC. 19. *Fair Average Quality Crude Cocoanut Oil.*—When crude cocoanut oil is sold as fair average quality price shall be adjusted upon the basis of an allowance of one-half of 1 per cent for each 1 per cent excess in free fatty acid over 6 per cent and a corresponding per cent in price for each 1 per cent or fraction thereof of excess moisture and impurities contained therein beyond 1 per cent.

SEC. 20.—Other crude cocoanut oil or refined cocoanut oil shall be sold on sample or guarantee, with the designation of the country of origin.

SEC. 21. All cocoanut oils sold under these rules shall be obtained by pressure, not extraction, unless otherwise specified.

Grades of Interstate Cottonseed Crushers Association are as follows:

COCOANUT OIL—GRADES

SEC. 3.—Choice grade Cocoanut Oil shall be what is known as "Cochin Grade" and shall be pressed and not extracted and should not exceed 2% free fatty acids, calculated as Oleic Acid, free from moisture and impurities, and shall have a color not greater than 6 yellow and .5 red.

SEC. 4.—Prime Crude Cocoanut Oil shall be pressed and not extracted and shall not contain more than 5% of free fatty acids, calculated as Oleic Acid, and shall be free from moisture and impurities and shall have color not greater than 30 yellow and 5 red, provided that any oil that tests with more than 5% of free fatty acids, calculated as Oleic Acid shall not be rejected but shall be reduced $\frac{1}{2}$ of 1 % of the contract price for each 1% of excess acid covered by the contract.

Other Crude Cocoanut Oil shall be sold on sample or guarantee.

Copra is pressed hot. The press cake is a valuable cattle food. It contains around 10 per cent oil and 20 per cent protein.

At ordinary temperatures cocoanut oil is a solid white fat. In warm weather it becomes much softer and may even become liquid.

Good grades of cocoanut are used for edible purposes, as for margarins, chocolate fats, vegetable butters, etc. Oil containing less than 3 or 4 per cent acid is specially refined to deodorize it, for such purposes. It may be pressed to remove some of the liquid fats contained. A stearine from cocoanut is used in candles, cocoa butter substitutes, pharmacy. The olein (or liquid fat) is used in soap making, bakers' fat, etc. Oil unfit for edible purposes is used for soap. Cocoanut, by reason of its high saponification number,¹ has a large

¹ See p. 116.

content of glycerin, around 13 to 14 per cent (depending, of course, on the free fatty acids).

Cocoanut has the property of forming "cold soaps" with caustic alkalies, that is, a soap is formed with alkalies without the agency of heat (as most other oils require). The soap is not precipitated or rendered insoluble by salt solutions, hence it makes a "salt water" soap.

It is not often adulterated, though palm nut oil is sometimes present. It, however, cannot be detected, and fills the same uses as cocoanut.

Characteristics

Specific gravity at 15° C.....	.926
Saponification number.....	246-268
Iodine number.....	8-10
Solidifying-point.....	16-23° C.
Melting-point.....	23-26° C.
Volatile acids (Reichert-Meissl) ¹ ...	6-8%
Titer.....	21-25° C.
Unsaponifiable matter.....	Up to .6%

Cocoanut stearine has a titer of 26° C., the oleine about 20° C.

Character of Seattle importations is shown by the following tables:

FREE FATTY ACIDS

	1-2 Per Cent.	2-4 Per Cent.	4-6 Per Cent.	6-10 Per Cent.	8-10 Per Cent.	Over 10 Per Cent.
Jan. to June, 1918, per cent	1	14	61	24		
June to Aug., 1918, per cent	....	25	58	14	2	1

¹ See p. 20.

WATER

	Under 0.5 Per Cent.	.5-1.0 Per Cent.	1-2 Per Cent.
Jan. to June, 1918.....	0	88	12
June to Aug., 1918.....	.....	95	5

Insoluble impurities nearly always are under 0.2 per cent, but occasionally exceed 0.5 per cent. .

The following are analyses of composite samples of oil of different grades and origin:

	Cochin.	Ceylon (Manila).	Ceylon (Japan).
Free fatty acids, per cent....	2.6	6.2	5.5
Saponification number.....	254	257	257
Iodine number.....	9.6	8.8	8.9
Moisture, per cent.....	0.4	0.61	0.49
Melting-point, deg. C.....	.....	26-28	26-27
Titer, deg. C.....	23.3	22.7	22.4

Japan Wax

From berries of the sumach tree in China and Japan. These trees are grown for the lacquer which they exude. It is not a true wax, but a fat, as it contains glycerin.

Hard, pale yellow, conchoidal fracture. Can be kneaded with the finger like wax.

Commercial varieties may contain 15 to 30 per cent water. Starch up to 25 per cent has been found. This, of course, is an adulteration.

It is used in polishes, floor wax and for currying and finishing leather.

Characteristics

Specific gravity at 15° C.....	.975
Saponification number.....	220-240
Iodine number.....	4-15
Melting-point.....	50-54° C.
Solidifying-point.....	48-50° C.

ANIMAL FATS

With few exceptions animal fats are non-drying, that is, they do not absorb oxygen, and have a low iodine number. Icebear fat has an iodine number of 150, and rattlesnake fat of 105, and these might be classed as drying fats.

The most important animal fats are lard, beef tallow, mutton tallow, and butter. It has been proven by experiment that the character of animal fats is influenced largely by the kind of food the animal eats. Furthermore, certain substances in the food pass directly into the animal fat. Thus it has been found that the substance, which in cottonseed oil produces a color in the Halphen test, is found in the lard of a hog fed upon cottonseed meal. The same has been found in the milk of a cow. Not only cottonseed but also sesame oil acts the same way. Because of this influence of the animal's food, the characteristics of animal fats vary more than do those of vegetable fats, and as a consequence the detection of adulterations is more difficult.

Lard (from the fat of the pig)

The following grades are recognized in the United States: (1) Neutral lard, from the leaf of the pig,

rendered between 40 and 50° C., contains up to 0.25 per cent free fatty acids. Sometimes divided into one and two grades. Neutral lard No. 1 is prepared from the leaf. Neutral lard No. 2 is prepared from the back fat. (The leaf is the portion surrounding the kidneys and bowels.)

(2) Leaf lard, rendered from the residue left from the neutral lard by steam heat and pressure.

(3) Choice kettle rendered lard, rendered in steam-jacketed open kettles from portions of leaf and back not used for neutral lard.

(4) Prime steam lard rendered by steam from head, heart and small intestines. It may also contain fat from other parts.

The United States Department of Agriculture defines lard as follows:

1. Lard is the rendered fresh fat from hogs in good health at the time of slaughter, is clean, free from rancidity, and contains, necessarily incorporated in the process of rendering, not more than one per cent of substances, other than fatty acids and fat.

2. Leaf lard is lard rendered at moderately high temperatures from the internal fat of the abdomen of the hog, excluding that adherent to the intestines, and has an iodine number not greater than 60.

3. Neutral lard is lard rendered at low temperatures.

The New York Produce Exchange defines Standard Prime Steam Lard as follows:

RULE 2. Sec. A.—Standard Prime Steam Lard shall be solely the product of the trimmings and the fat part of the hog, rendered in tanks by the direct application of steam and without subsequent change in the grain or character by the use of agitators or other machinery, except as such change may unavoidably come from the transportation. It must have proper color, flavor, dryness, and soundness for keeping, and no material which has been salted must be included. All lard must be

rendered in conformity with the rules and regulations of the United States Department of Agriculture. The name and location of the renderer, the date of packing, and the grade of Lard, shall be plainly branded on each package at the time of packing.

Sec. B.—Prime Steam Lard of superior quality as to color, flavor and body may be inspected as "Prime Steam Lard, Choice Quality," and shall be deliverable on contracts for "Prime Steam Lard."

The definitions of the Chicago Board of Trade are practically the same.

Neutral lard does not keep as well as the steam-rendered varieties because of the lower temperature at which it is made.

No. 1 grade is used in oleomargarine. The second quality is used by confectioners. Lard is also used in pharmacy and perfumes. After the edible grades of lard have been obtained, the remainder is worked up for any fat left. This grease is used for soap, lard oil, stearine, etc.

Lard oil is obtained by pressing out the liquid fat of lard. It is used for compound lards, margarine; non-edible grades are used for lubricating, wool oil, burning oil, silk scouring. The residue left after pressing out the lard oil, is lard stearine. It is used in candle manufacture, etc.

Lard compound is made by thickening cottonseed oil with oleo stearine, or with other stearines, to get the proper consistency. Oleo stearine is made by pressing beef tallow. Vegetable stearines, or hydrogenated oil, may be used in place of oleo stearine.

All of the above characteristics are influenced largely by the food of the animal, so that the detection of adulteration in lard is often a very difficult matter.

Characteristics of Lard and Lard Oil.

	Lard.	Lard Oil.
Specific gravity at 15° C.....	.934-.938	.913-.919
Saponification number.....	195-203	190-198
Iodine number.....	47- 85	67- 88
Melting-point, deg. C.....	36- 48	
Solidifying-point, deg. C.....	27- 30	-4 to +10
Titer, deg. C.....	19- 36	

Bone Fat

Obtained from bones by boiling, steaming, or extraction by solvents. Latter process yields bad smelling oil unsuitable for soap and used in candles only, or very cheap soap.

Bone oil is obtained from bone fat the same as lard oil is obtained from lard, and is used as a lubricant on account of its low cold test, and also, in the leather industry, in a similar manner to neat's-foot oil.

It is very low in free fatty acids.

Characteristics of Bone Fat

Specific gravity at 15° C.....	.914-.916
Saponification number.....	191-195
Iodine number.....	46-56
Melting-point.....	21-22° C.
Solidifying-point.....	15-17° C.

Tallow (Either from Beef or Sheep)

Tallow is classified as edible or inedible and also by the name of the animal.

Beef Tallow

For edible grades, as for margarine use, the kidney fat (suet) is used. In freshly rendered tallow the free acids

are less than 0.5 per cent, but poor grades may contain over 25 per cent.

Tallows are generally sold on titer, acids, non-fatty matter and color test. The determination of water is also important. Besides the edible uses, it goes into soap, candles and greases. The higher the titer test the more valuable it is for soap and candles.

Tallow used to be the chief soap-making fat, because of its high titer and availability. Since hydrogenated oils are becoming so common, the soap maker is not so dependent on tallow.

Candle makers do not want the titer below 44° C. Tallow of lower titer is used for soap. For railway axle grease the titer should not be below 41° C. Tallow is sometimes adulterated with mineral matter and other foreign ingredients.

Mutton tallow has a stronger odor than beef tallow, and cannot be used in margarine or high-class soaps. It is harder, with a higher titer test, solidifying- and melting-point. It is sometimes sold mixed with beef tallow. It has more tendency to turn rancid than beef tallow.

Characteristics of Beef and Mutton Tallow:

	Beef.	Mutton.
Specific gravity at 15° C.....	.943-.952	.937-.953
Saponification number.....	193-200	192-195
Iodine number.....	35- 47	33- 34
Titer, deg. C.....	43- 45	43- 46
Solidifying-point, deg. C.....	27- 35	32- 41
Melting-point, deg. C.....	40- 48	44- 49

Oleo stearine or beef stearine is the stearine obtained by pressing tallow.

Oleo oil or tallow oil is the resultant liquid fat.

Oleo stearine is largely used in lard substitute, oleomargarine, etc.

Oleo oil is used in oleomargarine.

Horse Fat

Sometimes used for edible purposes in place of lard, but its chief use is in soap. Characteristics similar to lard or tallow. Iodine number is higher, 75 to 86.

Butter Fat

While butter has in general no place in the oil trade, the characteristics are herewith given for comparative purposes:

Characteristics

Specific gravity at 15° C.....	936-.940
Saponification number.....	221-233
Iodine number.....	25-50
Melting-point.....	28-33° C.
Solidifying-point.....	19-24° C.

According to United States Department of Agriculture rules, butter must contain not less than 82.5 per cent milk (or true butter) fat. To comply with this rule the water cannot be over 16 per cent.

Butter Substitute. Oleomargarine¹

Mixture of animal fats (such as oleo oil or neutral lard, or beef stearine), and vegetable fats, in oils such as

¹ See also p. 107.

cottonseed oil or cottonseed stearine. Oleo oil is churned with vegetable oil or fat and with pasteurized skim milk. Sometimes butter flavor or color is added.

Renovated Butter

Process butter is the product made by melting butter and reworking, without the addition or use of chemicals or any substances except milk, cream, or salt, and contains not more than 16 per cent water, and at least 82.5 per cent of milk fat.—U. S. Dept. Agriculture.

Waxes

Waxes are distinguished from oils and fats in that they do not contain glycerin, or at least only in smaller amounts. They are combinations of fatty acids (which are in general the same as those of oils and fats) and higher alcohols (the alcohols replacing glycerin).

The waxes yield large amounts of unsaponifiable matter, which in this case consists mainly of the higher alcohols.

Liquid Waxes

Represented by sperm oil.

Sperm Oil

This is classed as a liquid wax because it does not contain glycerin, thus distinguishing it from other oils. It is obtained from the head cavity and blubber of the sperm whale. The head oil is worth more than the blubber oil. The two are sold in the proportion of one-third head and two-thirds blubber oil as No. 1 sperm oil. The body oil of sperm is graded as No. 2

and 3 oil, and contains considerable amounts of free fatty acids.

The oil is subjected to cold to settle out the spermaceti, and then filter pressed. This gives winter sperm oil, standing a cold test of 38° F., the usual standard. By further pressing, oils of higher cold test are obtained such as "spring" and "taut" sperm oil. The press cake is crude spermaceti.

Pacific coast grades of sperm oil are as follows:

No. 1, one-third head, two-thirds blubber oil, acids up to 2 per cent, specific gravity not over .884.

No. 2, body oil, acids up to 5 per cent.

No. 3, body oil, acids up to 15 per cent.

As the specific gravity of sperm oil is low, a high gravity points to admixture of other oils. No. 1 sperm oil is specified to have a gravity of not over .884 at 15.5° C. Spermaceti will also raise the gravity.

Inasmuch as the presence of mineral oil cannot be detected in sperm oil by simple determination of the percentage of unsaponifiable matter, there is an inducement sometimes towards adulteration in this way. Mineral oils can be detected by special methods of examination of the unsaponifiable matter, such as acetylation.

Sperm oil is a valuable lubricating oil. It has very little tendency to gum. The viscosity does not decrease with increase of temperature so rapidly as other oils, which makes it specifically valuable for high temperature work. It is also used in leather finishing.

Arctic sperm oil or bottlenose oil has more of a tendency to gum, and brings a lower price.

Characteristics

	Sperm.	Arctic Sperm.
Specific gravity at 15.5.....	.844-.884	.876-.881
Saponification number.....	123-150	121-136
Iodine number.....	76-96	67-85
Titer, deg. C.....	11.1-11.9	8.3-8.8
Flash-point.....	390-485°	
Unsaponifiable matter, per cent....	37-44	31-43

Solid Waxes**CARNAUBA WAX**

From leaves of a palm in South America, chiefly in Brazil. Obtained by melting in boiling water. Used in polishes, candles, varnishes, waterproofing, etc. Gives very good luster in polishes. May be adulterated with paraffin, stearine, etc., which can be readily detected. Free fatty acids up to 2 per cent.

Characteristics

Specific gravity at 15° C.....	995-1.00
Melting-point.....	83-91° C.
Solidifying-point.....	80-87° C.
Saponification number.....	78-88
Iodine number.....	13-14

Wool Wax or Wool Grease

Removed from wool by scouring with soap, or by solvents.

It has the property of mixing with water and finds use in pharmacy and cosmetics, when refined. The refined products are adeps lanae and lanolin. Adeps lanae

is free from water, and lanolin is mixed with 20 to 25 per cent water.

The crude product is known as brown grease, recovered grease or, in the United States as degreas, and is used in currying leather. Distilled wool grease is made by distilling with steam. The liquid portion is used as a wool oil, the solid portion for soap and candles.

Characteristics

Solidifying-point.....	Around 30° C
Melting-point.....	31-42° C
Saponification number.....	82-130
Iodine number.....	17-52
Unsaponifiable matter.....	43-52%

Beeswax

Secreted by bees. Used in candles, polishes, etc.

Characteristics

Melting-point.....	62-70° C.
Solidifying-point.....	60-63° C
Saponification number.....	90-107
Iodine number.....	8-14
Unsaponifiable matter.....	52-56%

Spermaceti

From the head cavity of the sperm whale. See sperm oil.

Used for candles, cosmetics, etc.

Brittle, white, translucent. Crude sperm oil yields about 10 per cent spermaceti. The crude press cake from the sperm oil pressing is melted and refined with caustic soda.

Characteristics

Specific gravity at 15° C.....	.942-.960
Saponification number.....	120-135
Iodine number.....	3-7
Melting-point.....	41-46° C.
Solidifying-point.....	41-49° C.
Unsaponifiable matter.....	49-53%

Insect Wax (Chinese Wax)

Secretion of an insect in Western China. Yellowish white, resembles spermaceti, but is harder and can be powdered more easily. Used in China and Japan for polishes, sizing for fabric, candles.

Characteristics

Specific gravity at 15° C.....	.970
Melting-point.....	80-83° C.
Solidifying-point.....	80-81° C.
Saponification number.....	80-93
Iodine number.....	1-2
Unsaponifiable matter.....	49-51%

CHAPTER III

USES OF OILS

In the following section the various uses to which oils are put will be briefly discussed.

Edible Oils

For general discussion see page 10.

Salad Oils

Common oils in use in the United States are: Cotton-seed, corn, olive, peanut, sesame, soya. Almost all vegetable oils are used in different countries except certain oils which have toxic effects, such as castor, China wood, croton, etc.

Salad oils are often a blend of several oils. It is specially important that salad oils be freed previously from stearine, so that none will separate out on the table. They must be low in acids, free from rancidity and of good taste.

Besides salad oils, oils are used somewhat in cooking and baking, though in this country the use of solid fats is more common for these purposes.

Edible Fats

Commonly used fats are lard, butter, tallow (suet), cacao butter.¹ An edible fat must be low in acids, free from rancidity, and of good taste.

¹ Solid vegetable fats are considerably used for edible purposes in their native countries.

The higher-priced edible fats are often replaced by substitutes. Hydrogenated oils are playing an increasingly important part as edible fats and are used in all the following, as well as the natural products.

(1) Tallow substitutes; mixtures of tallow or beef stearine, with cottonseed oil, cottonseed stearine, coconut oil, or other edible oils.

(2) Butter substitutes: Margarines, mixtures of animal and vegetable fats.

Oleomargarine: (See page 100, under Butter.) Made from oleo oil (pressed from beef tallow) or neutral lard, churned with vegetable oils and pasteurized skim milk. Vegetable oils used in oleomargarine are cottonseed, sesame,¹ peanut, soya and corn.

Margarines are also made which consist exclusively of vegetable oils. Coconut or palm nut oil is usually the base of these, sometimes cottonseed stearine. Coconut oil is refined and deodorized by processes which are generally kept secret. Sometimes coconut oil is emulsified with water, eggs, milk, salt, to make the product more like butter.

(3) Lard Substitutes: Mixtures of lard or lard stearine, with beef or mutton stearine, cottonseed stearine, cottonseed oil, corn, peanut, sesame, coconut and palm nut oils. Such mixtures are labeled as "lard compound" in the United States.

(4) Cacao Butter Substitutes: Chocolate fats, substitute for cacao butter in cheap chocolate or in confectionery where more fat is required than would be furnished by the chocolate. Animal fats in general are not suitable. Coconut oil, palm nut oil, or stearine

from these, to give required consistency, are used. Sometimes waxes have been added as stiffeners.

Oils for Medicinal Purposes

Castor and cod liver oils are the two most commonly used.

Various preparations are made of castor and cod liver oils to make them more palatable as e.g., effervescent oil, i.e., saturated with carbon dioxide, mixtures with milk, gum arabic, etc.

Phosphorized oils are treated with phosphorus, the phosphorus dissolving in the oil. Almond oil is so treated.

Iodized and brominated oils have been treated with iodine and bromine.

Burning or Illuminating Oils

Almost every kind of oil has been used for this purpose in different countries. Use of vegetable and animal oils has been decreased much by petroleum oils. Lard, whale, seal, rape and olive are still used in various countries. Drying or semi-drying oils are not suitable, because of gumming tendency. Acids should be less than 5 per cent. High acid oil causes charring of wick and smoky flame. Mineral acid (from refining) should be absent. Mucilaginous or insoluble matter tend to clog the wick.

Paint Oils

Drying oils only are suitable. Linseed is the best and oldest paint oil. Walnut and poppyseed are used for high-grade paint. China wood, soya, corn and men

haden are also used.¹ China wood is used after heating and the addition of a drier. Other semi-drying oils are sometimes used as adulterants.

Extracted oils are not suitable for the best paint.² Most paint oils are used in the form of boiled oils (see pages 36, 111).

Lubricating Oils

Before the introduction of petroleum oils, vegetable and animal oils and fats were exclusively used for lubricating. Their use is not now so common. Tallow oil, lard oil, neat's-foot, castor, rape, olive, tallow, sperm, porpoise and dolphin are used. Drying and semi-drying oils are not used because of their tendency to gum.³ A lubricating oil should be free from mineral acids and low in free fatty acid. Viscosity is very important, as it is chiefly to their viscosity that oils owe their lubricating value. The viscosity must not be too greatly decreased by heating. Lubricating oils should have a high flash-point⁴ and burning-point, and a low freezing- or solidifying-point. The specifications for these latter properties depend on the specific use to

¹ There are a number of other oils which give good promise of becoming important drying oils, such as perilla, hempseed, candlenut, or lumbang, stillingia, etc. Use of these oils will be extended as new ways of applying them are found.

² For tests as to the suitability of an oil for paint use, see pp. 34, 35, 44, 111.

³ Another important objection to drying oils would be their tendency to spontaneous combustion on cotton "waste."

⁴ The flash point is the temperature at which the oil first catches fire, determined by trying the surface with a flame. The oil is heated during the test either in an open or closed cup. Burning point is the temperature at which the oil continues burning.

which the oil is to be put and the climatic conditions of the place where it is to be used. A cylinder oil needs a higher flash-point than a bearing oil. The former should not be below 500° F. and the latter 350° F.

Wool Oils, Cloth Oils

Used for lubricating the fibers of the wool previous to spinning. Olive oil, lard oil, neat's-foot oil, and oleic acid are used. Wool grease, distilled grease, and seek oil may be used. Seek oil is the recovered grease from scourings of silk, wool or cotton goods. Drying and semi-drying oils are unsuitable, as these would have a tendency to cause spontaneous combustion. Wool oils must be easily removable by scouring, therefore the unsaponifiable matter should be low. Flash-point should be high.

Hydrogenated or Hardened Oils or Fats

Almost all liquid oils can be changed to hard fats by the action of hydrogen on the oil in the presence of a substance called the catalyst. Nickel is one of the most commonly used catalysts. The oil is deodorized in the process. It is difficult or impossible to tell what the original oil was after hardening.

The melting-point or titer of the product can be controlled in the process to produce any desired result. This is of great advantage to the soap and candle maker. Hardened oils and fats are used in margarines, lard substitutes, soap, candles, etc. Those intended for edible purposes should of course fulfill the same specifications as other edible oils. The presence of metals, left in the oil from the hydrogenating process, if in too

large amount will prevent their use for edible purposes. Only traces of these metals are permissible. Nickel in hardened fat runs generally less than 0.01 per cent, some as low as 0.003 per cent.

There is considerable advantage in shipping hardened oils over liquid oils, as there is no danger of loss by leakage.

Boiled Oils

Formed by heating drying oils with substances called driers, such as manganese, cobalt, and lead compounds. These latter hasten the absorption of oxygen when the oil is exposed in a film, as in paints and varnish.

Linseed oil is most commonly used. Perilla and menhaden are satisfactory. Candle nut, hempseed, soya, china wood, poppyseed are not as satisfactory.

A practical test for the suitability of a drying oil is to heat it to 300° C. rapidly. In this test it should remain clear. An oil not suitably refined will separate out a sediment in this test.

Boiled oils are used in varnishes, paints, enamels, etc.

Varnishes

Mixtures of boiled oils with gums or resins (such as damar, copal, rosin, etc.), and turpentine or other thinner. China wood oil is finding an increasing use in varnishes.

Linseed oil has always been the standard oil for varnishes.

Lithographic varnish, or oil, is linseed oil which has been heated to 250 to 300° C., but has not had a drier added. The thickness depends on time of heating.

Enamels are mixtures of varnishes with pigments.

Paints are mixtures of boiled oils, pigments and thinner.

Blown Oils, Oxidized Oils

Oils through which a current of air, oxygen or ozone has been blown. Drying and semi-drying oils, either animal or vegetable, are suitable for blowing. Blown oils are higher in gravity and viscosity than the original oil, that is they become thicker. The viscosity approaches that of castor, and such oils are sometimes called "soluble castor oil" because they are soluble in petroleum oils, whereas castor oil is not.

Corn, cottonseed, rape, seal, sperm and fish oils are blown for use in lubricants, and to some extent in leather.

Blown linseed oil (along with other drying oils), is used in linoleum, by mixing with various gums or resins. For this purpose the oil is blown until it forms a solid.

Rubber Substitute, Vulcanized Oils

By the action of sulphur or sulphur chloride on certain oils, solid masses, somewhat like rubber in consistency are formed. These are used in compounding rubber goods.

Rape, castor, corn, soya, peanut, sesame and linseed oils are so used. Nitrated oils also are used as rubber substitute.

Nitrated Oils

Linseed or castor oil treated with nitric acid form thick heavy liquids. Solutions of these in acetone are

used in paints, varnishes and enameled leather, and as rubber substitute.

Sulphonated Oils

Turkey red oil¹ used in dyeing and printing cotton fiber is a sulphonated oil, that is, one that has been treated with sulphuric acid. Castor oil so treated forms the original Turkey red oil. Olive, peanut and cottonseed oils are also used. The value of a Turkey red oil depends on its action towards the fiber on which it is to be used, in fixing dyes. Turkey red oil is also used as a wool oil.

Candles.

In the manufacture of candles, fats are first saponified by various processes, and the mixed fatty acids obtained separately from the glycerin. The mixed fatty acids consist of solid acid as stearic acid or stearine, and liquid acids as oleic acid. The latter are of no use to the candle maker. The mixture of acids is pressed to free the stearine from the oleic or liquid acids. Distillation of the oleic acid is also used as a means of separation. Oleic acid is a by-product.

By such means stearine of the required consistency or melting-point is obtained. The higher the titer test therefore of a fat, the higher will be the yield of stearine suitable for candles. The titer test is the solidifying-point of the total fatty acids of an oil or fat.

Tallow, bone fat, palm oil, cottonseed stearine, vegetable tallow and artificially hardened oils and fats are all used. Waxes such as spermaceti or beeswax are used

¹ See p. 68.

in stiffening, as are also mineral wax such as paraffin, ceresin, etc. Paraffin has come to be a very important ingredient of candles, and has somewhat lessened the importance of vegetable and animal stearine for this purpose.

Fatty Acids

Stearine is the name applied to the mixture of solid fatty acids, obtained as in candle making. It is a mixture of stearic and palmitic acids. Besides its use in candles, it is used in polishes, waterproofing preparations, phonograph records, etc. Low grades may be used in soap.

The name stearine is also applied to solid fats separating out naturally from liquid oils. This "stearine" is a solid fat instead of a solid fatty acid, that is, it is a combination of a solid fatty acid (e.g., stearic acid) and glycerin.

Oleic acid, oleine, eleine, or red oil, is the name applied to the liquid fatty acids, separated in candle making. Saponification oleine is obtained by refrigeration and pressing; distilled oleine by the distillation process. It is used in soap making and for wool oils.

Soap Stock Fatty Acids

These are prepared from fats by saponification in establishments whose chief aim is the recovery of glycerin. The fatty acids resultant are used by soap makers. This gives the small soap maker the material which he needs for soap, and does not compel him to recover the glycerin, thereby removing a handicap which he would have in competing with large soap

factories which can well afford to recover the glycerin, because of the scale on which they operate. Almost any oil is used by plants making soap stock acids,

Soap

Soap is a combination of the fatty acids of oils or fats with a base such as an alkali (potash, soda, ammonia) or alkaline earth (lime, magnesia, etc.), or metals (aluminum, iron, lead, etc.). The character of the resultant soap depends both on the base and on the oil used, so that a great variety of soaps may be made. Almost all oils are used in soap.

Soda gives a harder soap than potash. The drying oils (linseed, hempseed, fish) give soft soaps. Solid fats give hard soaps. The semi-drying oils (cottonseed, etc.) may be used as admixture in both soft and hard soaps depending on the consistency desired.

Oils and fats are valued by the soap maker on the amount of unsaponifiable matter they contain. A common determination required by the soap maker is what is known as *min*, which stands for moisture, insoluble sediment (or dirt) and unsaponifiable matter. None of these of course will make soap. When glycerin is high priced the amount of glycerin which an oil contains also influences the value of it to the soap maker. (See glycerin for method of estimating.)

Soaps are made to fit special uses, as toilet, laundry, textile soaps.

Glycerin

The glycerin in combination with the fatty acids of an oil or fat, is obtained by the soap and candle maker as a by-product.

The amount of glycerin in an oil is not a fixed quantity. Oils contain mono-, di-, and tri-glycerides. That is, one, two, or three equivalent weights of fatty acids, are united with one equivalent of glycerin. The percentage of glycerin in a tri-glyceride is less than in a mono-glyceride. The tri-glycerides are, however, the chief constituents of natural oils, and therefore the amount of glycerin can be approximated from the saponification number, as follows:

Subtract from 100 the combined percentage of water, insoluble and unsaponifiable matter. Divide the saponification number determined on the oil by the remainder, giving the approximate saponification number of the neutral oil. Multiply by 10, divide by 183, giving the approximate percentage of glycerin in the neutral oil. Subtract from 100 the combined percentage of water, insoluble and unsaponifiable matter, and free fatty acids, and multiply the percentage of glycerin in the neutral oil by this remainder, giving the glycerin percentage in the original oil.

Take for example the following analysis of an oil:

Water.....	2.0%
Insoluble matter.....	0.2
Unsaponifiable matter.....	2.0....sum 4.2
Free fatty acids.....	4.0....sum 8.2
Saponification number.....	195

$$100 - 4.2 = 95.8$$

$$\frac{195}{95.8} = 203 \text{ saponification number of neutral oil.}$$

$$\frac{203 \times 10}{183} = 11.1 \text{ per cent glycerin in neutral oil.}$$

$$11.1 \times (100 - 8.2) = 11.1 \times 91.8 = 10.2 \text{ per cent glycerin in original oil.}$$

A shorter method is to multiply the saponification number by $\cdot 10$ and divide by 183, and then multiply by the percentage of neutral oil, i.e., 100 per cent minus the sum of the water, insoluble, unsaponifiable and free fatty acids. This method is not as accurate as the foregoing.

The percentage of glycerin can of course be determined accurately by chemical methods.

The cocoanut group of oils have the highest percentage of glycerin, and the rape oil group the lowest.

Polishes

Mixtures of waxes, stearine, oils, with solvents such as turpentine.

Foots, Soap Stock

Foots are residues or sediments from the refining of oil. They consist of impurities such as mucilaginous matter, water, dirt in the original oil, and stearine (or solid fat). When alkalies are used in refining, a soap is formed with the free acid in the oil, and this is also contained in the foots. Some neutral oil is always entangled with it. Cottonseed soap stock¹ is such a product. The character of foots depends on the refining process used on the crude oil.

Black grease is the fatty matter obtained by treating soap stock with acid (also called acidified soap stock).¹

Greases

Waste fats from garbage, slaughter houses, etc., stearine from whales and fish, are worked into grease, which is a

¹ See p. 53.

general name for low grade, more or less solid fats. Greases are used in candles, soap, lubricants, etc., depending on their character. (See also wool fat.)

Sod Oil, Degras

In the chamoising process of treating skins, whale, menhaden and cod oil are rubbed into the skins. They are then left to ferment for some time, and afterwards the excess oil is separated. The oil so obtained is very different than the original oil. It contains water and other impurities, and is used in dressing leather. Sometimes skins are worked for the sole purpose of preparing degreas or sod oil.

Degras is the heavy grease first obtained from the skins. After this is collected (by pressure) the skins are washed with alkali, and the solution so obtained neutralized with sulphuric acid, giving sod oil. The foregoing applies to European practice.

The name "degreas" in the United States is applied to the grease from wool scouring.

Fish oils, tallow and various greases are sometimes substituted for degreas or sod oil.

Degreas or sod oil is valued on the amount of water, impurities and unsaponifiable matter. They are used in the treatment of leather.

Stuffing grease is a mixture of degreas with tallow, fish stearine or other waste fats, sometimes soft soap. It is used in tanning.

CHAPTER IV

SAMPLING

THE correct sampling of oils is a very difficult matter, and one that requires very careful attention. It is frequently done, however, in a careless manner, and perhaps there is no other one reason that causes so many misunderstandings and disputes in the oil trade as incorrect samples. Practically all oil, it may be said, is sold on the basis of sample submitted to the buyer by the seller, or on analysis of sample by a chemist. If now the sample does not correctly represent the lot of oil which is being offered for sale, trouble is sure to arise, and this is the cause of most of the "claims" in the trade. The buyer very seldom sees the lot of oil he buys until it is delivered to him.

One of the chief difficulties in getting a correct sample of a lot of oil is the presence of water, foots, insoluble matter of various kinds, etc. After oil has been standing for some time, or has been shipped some distance, these settle to the bottom of the container, and to get a correct sample must again be mixed with the bulk of the oil. This often is very difficult and even impossible practically, and so methods of sampling have to be employed in practice which will approximate as nearly as possible an accurate sample.

Methods of sampling vary with the kind of container. What is applicable to one is not to another. The

various sampling methods will be discussed therefore according to the kind of container.

Tank Cars.

The time to take an accurate sample of a tank car is during loading, or immediately after the car is loaded. While the stream of oil is running into the car, a dip may be taken from the stream of oil at regular intervals, and all the samples thus obtained combined into one composite sample after careful mixing. Immediately after the car is loaded the oil is pretty well mixed in the car. Even at this time, however, it is not safe to take one dip in the car and take this as the sample, for if the first oil which went into the car is different than the last, only an imperfect mixture of the two layers will have taken place in the loading process, and one dip will not give an accurate sample. If, however, a dip is taken out of about six different layers from top to bottom of the car, and all these dips combined into one composite sample, this composite will be a very accurate sample of the contents of the car. These separate dips can be very conveniently taken by a can fastened at the end of a pole, with a stopper arranged to be withdrawn when the desired depth has been reached. The bottom dip should always be taken as near the bottom of the tank as possible. Most tank cars have a sump in the bottom, into which the sampling can may be inserted, thus getting the oil at the very bottom of the car.

Sometimes a trier or thief with a closing valve on the bottom is used on tank cars, but this is very cumbersome to handle, and for this very reason is liable

not to take an accurate sample. Another objection to it is the difficulty in cleaning it between samples. Sampling instruments must always be kept clean. A trier or thief without a valve on the bottom which may be closed when the bottom of the tank is reached, is absolutely worthless. A thief does not take a sample proportional to the mass of the oil in the various layers from top to bottom of a cylindrical container, but takes the same amount out of each layer regardless of the fact that a foot of depth in the middle represents much more oil than a foot of depth at either the top or the bottom. In sampling by dip cans this may be compensated for, if desired, by combining the dips in different proportions in making up the composite sample.

After a tank has stood for a time, or especially after it has been shipped for a distance, the water and insoluble matter settle to the bottom. If there is much insoluble matter and the car has come a long way, the insoluble matter may become packed, as it were, in a layer on the bottom. It is then very difficult to dislodge or to mix with the bulk of the oil in order to get a uniform mixture. It is very seldom practical in any case to attempt to make a uniform mixture of the contents of a tank car for sampling purposes. Compressed air is sometimes tried as a means of agitation, but in this process water may either be added to the car or abstracted from it, depending upon the temperature of the oil and the degree of wetness of the compressed air.

The best way to take an accurate sample of a car which has settled into two layers is to draw off the two layers separately in unloading the car, taking samples

from the stream of oil at regular intervals of time. If, for instance, the upper or clear layer is unloaded first, it is sampled regularly, and at the point where a change is noticed in the character of the oil running, the unloading is stopped long enough to measure the volume remaining in the tank. After unloading commences again, a second series of samples is taken from the bottom oil. These two series of samples are each combined into separate composites, and analysis made of each. Knowing the volume of each layer, the average for the car can be readily computed. More than two layers can be thus sampled if desired.

The difficulty of sampling accurately a tank car on delivery disappears if the oil does not carry any amount of water or insoluble matter. The car may then be sampled by a dip method as described above, taking care to mix the bottom dip with the others in the correct proportion to represent the proportional volumes.

When the contents of tank cars are solid, as in the case of cocoanut oil in cold weather, it is best to sample as above, after the oil has been warmed and is unloading.

Barrels.

It is generally not necessary to sample every barrel of a lot of oil. Usual practice is to sample one in every ten barrels, or ten per cent. In the case of a lot of oil which arises from more than one source, or in the case of a lot containing much water, it may be necessary to sample more frequently than one in every ten. Sometimes every barrel is sampled in the case of very "spotty" lots. In sampling barrels, the same precautions must be observed as noted above, to get

an accurate sample of the oil, water, and insoluble matter in the correct proportions. After a barrel has stood for a time the water and insoluble matter will be found at the bottom or one side, depending on the position in which the barrel has stood. Where an oil is "thin" enough to permit a remixing of the water, etc., with the bulk of the oil, the separated layers may be mixed by rolling the barrel back and forth until mixture is obtained. If, however, the barrel is entirely full of oil, with no air space at the top, it is difficult to get a good mixture in this way. In the case of very viscous oils, as for example, castor, China wood, etc., it is almost impossible to mix in this manner, without taking an unduly long time in the operation. Such oils are best sampled in barrels by a trier or thief run to the bottom. Even when a barrel has been mixed by rolling, the thief should be run to the bottom for the sample. Special precautions must be taken not to insert the trier any faster into the oil than the oil rises in the tube. If this rate of insertion is exceeded any water in the bottom of the barrel will be forced into the trier in undue proportion. This precaution must be specially observed in the case of oils of high viscosity. The various trier samples may then be combined into one composite sample representing the whole lot.

Cases.

Much oil is shipped from the Orient in what are called "case lots." Two 5-gallon oil cans are packed in a wooden case. It has been found by experience that an accurate sample may be obtained on most of such lots, by opening one can out of every twenty cases, or

what is called a five per cent sample. It is hardly practicable to sample more frequently than this, and is not often necessary. The best way to sample cases is to first withdraw one can from the case, mix thoroughly by up-ending a number of times, punch a small hole in the top and pour out a small quantity of the contents. Special precaution must be used to mix well very viscous oils. Coconut oil, or other solid oil in cases, must be sampled by a trier. Case lots which have originated from more than one source may be spotty, and may need closer sampling than five per cent.

A more accurate sample may be obtained of a case lot when it is being dumped, if it is desirable to wait until such time.

Storage Tanks.

These are best sampled by the dip method as described under tank cars. The various dips should be taken at predetermined points in the depth of the tank. In the case of a cylindrical tank standing on end each dip represents an equal volume, and may be combined in equal proportions. In the case of a cylindrical tank lying on its side, the various dips should be combined proportionally to the volume which each represents.

Oil Seeds, Cake, etc.

Various methods may be used for such materials, depending on their nature. Seeds are generally sampled by inserting a trier. In the case of sacked seeds, the trier may be inserted into every tenth sack, to make a ten per cent sample. The trier used should be properly proportioned to the size of the seeds being sampled.

Cake may be sampled also by a trier. Copra cannot be sampled by trier. Sufficient sacks are opened and sample withdrawn by hand. It is a wise precaution to dump a number of the sacks and take part of the sample from the bottom of the sack.

The whole object of sampling is, of course, to get a sample in which all the various components will be represented in the same proportion in the sample as in the material being sampled. Too hard and fast rules can not be laid down for sampling methods; judgment and common sense must always be used. Sampling should never be entrusted to inexperienced men. The sampler must know the material he is sampling in order to secure an accurate sample. He must be able to decide on the best method of sampling when he arrives at the lot to be sampled. Oftentimes the manner in which a lot is stored on dock or in warehouse influences very much the manner in which the lot is to be sampled, and the sampler must be a man of sufficient judgment to work out a practical and at the same time as accurate a method as possible under the special conditions.

In almost any of the above methods of sampling from one gallon up to several gallons will be accumulated in the composite sample. This amount is generally larger than is needed for the sample. It is thoroughly mixed and the final sample taken out. When sending a sample to a chemist for analysis it is best to send at least a pint or quart. The practice of sending only a 4-ounce bottle is not good, as many times it does not afford the chemist sufficient oil for the required determinations.

Generally part of the sample taken is put in storage

until the lot of oil which it represents is finally disposed of. For storage 1-gallon tin cans are best. They should be kept in as cool a place as possible. Storage in glass bottles is not good. The light has considerable effect on the free fatty acid content, especially if they are exposed to sunlight. The free fatty acids will increase somewhat even when the samples are stored in tin cans. The table on p. 4 gives a number of results showing the variation in different samples in the increase of the free fatty acids.

After a sample has been stored for some time, and a portion of it is to be taken out, care should always be taken to shake the can well before pouring out. Misunderstandings have sometimes arisen because a sample was thoughtlessly poured off the top of a reserve sample.

PROPERTIES OF THE LESS COMMON OILS

Oil.	Iodine Number.	Saponification Number.	Melting- or Solidifying-point. Deg. C.	Country of Origin.	Use.
Acorn.	100	199			
Amoora.	135	190	.....	Bengal	
Anchovy.	160	188			
Anise seed.	105	178			
Apple seed.	135	202			
Apricot kernel.	105	192	- 20	.....	Edible
Arbutus.	148	208	- 27		
Areca nut.	15	230	35		
Argan.	96	192	.....	Morocco	Edible
Argemone.	120	188	.....	Mexico	Lubricant
Asparagus seed.	137	194	.....	.....	Edible and drying
Baobab.	70	190	10	Africa	
Barley.	90	280			
Beans.	85-115	185			
Beechnut.	115	195	.....	.....	Edible
Beef marrow.	50	198	30		
Ben.	95	179	.....	India	Cosmetic
Betu.	105	194	0-5	India, Africa	
Bilberry seed.	167	190			
Blackberry seed.	148	189			
Borneo tallow.	30	193	22	E. Indies	Edible
Brazil nut.	109	200	- 3	S. America	Edible, Soap
Brownfish.	111	224			
Buckthorn.	155	.....	.....	.....	Drying oil
Burdock.	154	197	.....	.....	Drying oil
Calophyllum.	90	195	4	E. Africa	Medicine
Candleilla Wax.	20	60	66	Mexico	
Carapa.	75	196	13	S. America	Soap
Carp.	84	202			
Caraway seed.	128	178	- 7		
Cay Cay.	5	236	32	Cochin China	Candles

PROPERTIES OF THE LESS COMMON OILS—*Continued*

Oil.	Iodine Number.	Saponification Number.	Melting- or Solidifying-point, Deg. C.	Country of Origin.	Use.
Celandine.....	127	198			
Celery seed.....	95	178	—12		
Celosia.....	126	190	.....	China	
Chaulmoogra...	100	210	titer 40°	Burmah	Medicine
Cherry kernel..	114	193	—20	.....	Soap, Burning
Chicken.....	65	193	25		
Clover seed.....	120	189			
Coffee berry....	87	175	5	E. Africa	Medicine
Cohune.....	75	197	.....	Mexico	
Colocynth.....	125	195	.....	Baluchistan	
Coriander seed..	100	182	—4		
Cottonseed wax..	12				
Coumon.....	80	190	—9	S. America	
Cranberry seed..	169	190			
Croton.....	104	210	.....	Asia	Pharmacy
Curcas.....	100	193	—8	S. America	Soap, Lubricant
Currant seed....	152	171			
Dab.....	118	185	.....	Japan	
Daphne.....	126	196			
Datura.....	113	190	.....		Burning
Dika.....	3	250	39	W. Africa	Soap, Candle
Dodder.....	140	187	—17	Europe	Edible, Soap
Dogwood seed..	100	192	—15		
Dugong.....	66	197	.....		Leather, Soap
Eel.....	107	148			
Elderberry.....	90	200	—5		
Elozy.....	85	180	5	Tropics	
Fir seed.....	100-160	190	—4 to —29	.....	Drying

PROPERTIES OF THE LESS COMMON OILS—*Continued*

Oil	Iodine Number.	Saponification Number.	Melting- or Solidifying-point, Deg. C.	Country of Origin.	Use.
Funtumia.....	138	185	.....	W. Africa	
Garden cress....	125	185	-15	.....	Edible
Garden rocket...	155	192	-22 to -23	France	Drying oil
Goose.....	80	190	20	.....
Grape seed.....	130	190	.....	.....	Edible, Soap
Gynocardia.....	152	198	.....	Assam, Bengal	Drying oil
Haddock liver...	154	188			
Hawthorn seed..	153	172	Below -17		
Hazelnut.....	90	193	-19	.....	Perfumes, Lubricant
Henbane seed...	138	171			
Hop seed.....	155				
Horse chestnut..	95	195	-20		
Hydnocarpus...	95	205	25	India	Medicine
Illipe.....	55	188	36	India	Candles
Inoy kernel.....	90	185	-5	W. Africa	
Inukaya.....	130	188	.....	.....	Drying
Jamba.....	100	175	-11	.....	Similar to rape
Japan wax.....	5	220	50	Japan	Polishes
Java almond....	63	197	12	Moluccas	
Java olives.....	83 _A	200	.....	Malayan Islands	
Kapok.....	120	195	.....	Tropics	Edible
Kaya.....	140	188	.....	Japan	Edible, Drying
Koeme.....	90	190	7	E. Africa	
Kokum butter..	30	190	37	India	Edible
Kombo.....	50	210	.....	Africa	
Lallemantia.....	162	185	-35	Russia	Drying oil
Laurel.....	75	200	25	.....	Medicine
Lemon seed.....	109	188			

PROPERTIES OF THE LESS COMMON OILS—*Continued*

Oil.	Iodine Number.	Saponification Number.	Melting- or Solidifying-point, Deg. C.	Country of Origin.	Use.
Lentil.....	111	183	-8		
Linaria.....	140	189			
Loofah seed....	108	193	.....	E. India	Edible
Lukrabo.....	85	210	25	China	
Lycopodium....	81	195	.....	.....	Edible
Macassar.....	50	230	10	India	Edible
Mackerel.....	167	190			
Madia.....	118	193	-10 to -17	Europe	Edible, Soap
Mafura.....	50	202	30	Africa	
Malabar tallow..	38	190	30	.....	Edible
Mani.....	64	194	.....	S. America	
Manihot.....	136	189	.....	Brazil, Africa	
Manketti.....	148	190	.....	W. Africa	Drying oil
Margos.....	70	197	.....	India	
Maripa.....	15	270	23	Brazil	Edible, Pharmacy
Millet seed....	130	184	-6		
Mkanyi.....	42	188	38	E. Africa	
Mocaya.....	27	188	8	Paraguay	
Mountain ash...	128	208			
Mowrah.....	60	190	20	India	Soap
Mucuna.....	104	178	3.5		
Mulberry seed..	140	190			
Mustard seed...	116	175	-15	.....	Edible
Myrtle seed....	107	200			
Myrtle wax.....	2	215	43	N. America	Soap, Candles
N'Gart.....	177-200	192	-16 to -33	Cameroons, Africa	Drying oil
Niam.....	70	190	.....	Africa	
Niger seed.....	134	190	-9	E. Africa	
Njave.....	55	188	.....	W. Africa	Candles

PROPERTIES OF THE LESS COMMON OILS—*Continued*

Oil.	Iodine Number.	Saponification Number.	Melting- or Solidifying-point, Deg. C.	Country of Origin.	Use.
Nutmeg.....	45	160	40	Java	
Ochoco.....	2	238	45	Africa	
Orange seed....	104	220(?)			
Owala.....	90	170-200	10	W. Africa	
Palm wax.....	52	65			
Para butter....	136	.....	.....	Brazil	Edible
Paradise nut....	71	173	4	Brazil	Edible
Parsely seed....	109	176	-14		
Pea.....	110	183	-14		
Peach kernel....	95	190	-20	.....	Substitute for almond
Pecan.....	106	198			
Persimmon.....	117	188	-11		
Phulwara.....	42	192	40	.....	Edible
Pistachio.....	87	191	-9	.....	Edible
Plum kernel....	95	190	-10	.....	Substitute for almond
Pongam.....	90	180	10	India	Medicine, Soap
Pumpkin seed...	120	189	-16		
Quince.....	115	185	-12		
Rabbit.....	105	203	30		
Radish.....	100	180	-15		
Raphia wax....	8	50	80	Madagascar	
Raspberry seed..	175	192			
Ravison.....	115	178			
Ray liver.....	115	192			
Rice.....	100	193	2	.....	Soap
Rubber seed....	130	200	.....	Brazil	
Rye.....	82	196			
Safflower.....	140	190	.....	India	Drying oil
Sasanqua.....	82	193	-9	Japan	Lubricant
Senega root....	80	194			

PROPERTIES OF THE LESS COMMON OILS—*Continued*

Oil.	Iodine Number.	Saponi- fication Number.	Melting- or Solidifying- point. Deg. C.	Country of Origin.	Use.
Shea butter.....	60	180	17	W. Africa	Candles
Skate liver.....	157	185			
Sorghum.....	99	172	40	Turkestan	Drying oil
Sprat.....	130	194	.....	.....
Staff tree.....	87	220	-5	Tropics	
Strawberry seed..	180	194			
Sunfish.....	102	148			
Sunflower seed..	130	190	-17	.....	Edible, Drying
Surin.....	42	179	49	Malay Penin.	Candles
Tangkallak.....	10	268	27	E. Indies	Candles
Thistle seed.....	140	189	.....	Asia	Edible, Drying
Tobacco seed...	119	190			
Tomato seed....	110	190			
Trout liver.....	155	190			
Tsubaki.....	81	191	-15	Japan	Lubricant
Tunny liver.....	156				
Ucuchuba.....	10	220	32	Brazil	
Vetch.....	107	180	-8		
Wallflower.....	124	180			
Watermelon seed	120	190			
Wheat.....	115	187	0		
White acacia....	161	192	.....	S. Russia	Drying oil
Whiting.....	127	201			
Yellow acacia...	129	190	.....	S. Russia	

WEIGHT PER GALLON OF OILS

Based on Average Specific Gravity at 15.5° C. or 60° F.

	Pounds.		Pounds.
Castor.....	8.0	Palm.....	7.7
China wood.....	7.85	Palm nut.....	7.6
Cocoonut.....	7.7	Peanut.....	7.65
Corn.....	7.7	Perilla.....	7.8
Cottonseed.....	7.7	Rape.....	7.6
Fish oils.....	7.7	Sesame.....	7.7
Hempseed.....	7.75	Soya.....	7.7
Lard.....	7.8	Sperm.....	7.35
Linseed.....	7.8	Tallow.....	7.9
Neat's-foot.....	7.65	Whale.....	7.7
Olive.....	7.65		

NOTE.—New York Produce Exchange specifies that cottonseed, olive, sesame, peanut, refined rapeseed and poppyseed oils shall be at the rate of 7½ lbs. per gallon.

COMPARISON BETWEEN SPECIFIC GRAVITY AND DEGREES BAUMÉ FOR LIQUIDS LIGHTER THAN WATER

Specific Gravity.	Degrees Baumé.	Specific Gravity.	Degrees Baumé.
.85	34.71	.93	20.54
.86	32.79	.94	18.94
.87	30.92	.95	17.37
.88	29.08	.96	15.83
.89	27.30	.97	14.33
.90	25.56	.98	12.86
.91	23.85	.99	11.41
.92	22.17	1.00	10.00

COMPARISON BETWEEN CENTIGRADE AND FAHRENHEIT
THERMOMETER SCALES

Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.
-30	-22	24	75.2	63	145.4
-28	-18	25	77.0	64	147.2
-26	-15	26	78.8	65	149.0
-24	-11	27	80.6	66	150.8
-22	-8	28	82.4	67	152.6
-20	-4	29	84.2	68	154.4
-18	0	30	86.0	69	156.2
-16	+3	31	87.8	70	158.0
-14	7	32	89.6	71	159.8
-12	10	33	91.4	72	161.6
-10	14	34	93.2	73	163.4
-8	18	35	95.0	74	165.2
-6	21	36	96.8	75	167.0
-4	25	37	98.6	76	168.8
-2	28	38	100.4	77	170.6
0	32.0	39	102.2	78	172.4
+1	33.8	40	104.0	79	174.2
2	35.6	41	105.8	80	176.0
3	37.4	42	107.6	81	177.8
4	39.2	43	109.4	82	179.6
5	41.0	44	111.2	83	181.4
6	42.8	45	113.0	84	183.2
7	44.6	46	114.8	85	185.0
8	46.4	47	116.6	86	186.8
9	48.2	48	118.4	87	188.6
10	50.0	49	120.2	88	190.4
11	51.8	50	122.0	89	192.2
12	53.6	51	123.8	90	194.0
13	55.4	52	125.6	91	195.8
14	57.2	53	127.4	92	197.6
15	59.0	54	129.2	93	199.4
16	60.8	55	131.0	94	201.2
17	62.6	56	132.8	95	203.0
18	64.4	57	134.6	96	204.8
19	66.2	58	136.4	97	206.6
20	68.0	59	138.2	98	208.4
21	69.8	60	140.0	99	210.2
22	71.6	61	141.8	100	212.0
23	73.4	62	143.6		

Boiling-point of water on the Fahrenheit scale is 212°, Centigrade, 100°. Freezing point of water, Fahrenheit is 32°, Centigrade, 0°.

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